U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-267 613

Reliability Study of Vapor Recovery Systems at Service Stations

Pacific Environmental Services, Inc, Santa Monica, Calif

Prepared for

Environmental Protection Agency, Research Triangle Park, N C

Mar 76

PB 267 613

EPA-450/3-76-001
March 1976

RELIABILITY STUDY OF VAPOR RECOVERY SYSTEMS AT SERVICE STATIONS

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality and Waste Management
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

163

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-450/3-76-001	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE: Reliability Study of Vapor Recovery Systems at Service Stations		5. REPORT DATE: March 1976
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): R. J. Bryan, R. L. Norton, L. G. Wayne		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Pacific Environmental Services, Inc. 1930 14th Street Santa Monica, California 90404		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-02-1405 Task Order No. 2
12. SPONSORING AGENCY NAME AND ADDRESS: U. S. Environmental Protection Agency Research Triangle Park, North Carolina 27711		13. TYPE OF REPORT AND PERIOD COVERED: Control Systems Evaluation
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

A study was conducted of the operational reliability of vapor recovery systems at gasoline service stations in San Diego County, California. Periodic inspections at 24 stations were conducted to examine the condition of these systems, to determine their operational status, and to check for detectable gasoline vapor losses from control equipment.

The study demonstrated that capture of vapors at the vehicle was more effective with vacuum-assisted systems than with vapor balance systems. However, the reliability of the vacuum-assisted systems was not good in general although there was substantial variation depending upon the type of unit.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Gasoline Marketing Service Station Vapor Recovery	Air Pollution Control Stationary Sources Mobile Sources Hydrocarbons	

18. DISTRIBUTION STATEMENT: Unlimited	19. SECURITY CLASS (This Report): Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS (This page): Unclassified	22. PRICE: PC A06 / MF A01

EPA Form 2220-1 (9-73)

EPA-450/3-76-001

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ENVIRONMENTAL PROTECTION AGENCY
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Research Triangle Park, North Carolina 27711

March 1976

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Publication No. EPA-450/3-76-001

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ABSTRACT

Pacific Environmental Services, Inc. (PES) conducted a study of the operational reliability of vapor recovery systems at gasoline service stations in San Diego County. This work was performed under EPA Contract No. 68-02-1405, Task Order No. 2. Periodic inspections of vapor recovery systems at twenty-four stations were conducted over the period May through July 1975 to examine the condition of these systems, to determine their operational status, and to check for observable gasoline vapor losses from control equipment. In all, 140 such inspections were made. During these visits, 506 vehicle refuelings were observed and the gasoline vapor capture effectiveness checked at the nozzle-vehicle filineck interface using a combustible gas analyzer.

The study demonstrated that capture of vapors at the vehicle as determined by the use of a combustible gas analyzer was more effective with vacuum-assisted systems than with vapor-balance systems. Gasoline vapor concentrations exceeding one tenth of the lower explosive limit were detected in fourteen percent of the vehicle refuelings where vacuum-assisted systems were used. The percent of refuelings exceeding the 0.1 LEL criterion among the individual manufacturers ranged from six to eighteen percent. For vapor balance systems, nozzle design strongly influences effectiveness. The number of refuelings where gasoline concentration at balance systems exceeded 0.1 LEL ranged from twenty-nine percent where better fitting nozzles were used to eighty percent where poorer fitting nozzles were used. The effect of greater capture efficiency of vacuum assist systems was offset to some degree by poorer reliability.

The reliability of the vacuum-assisted systems, as determined by the frequency of equipment malfunctions and gasoline vapor leaks at the vapor recovery units and vents, was not good although there were substantial variations in performance depending upon the type of unit and the location. Specifically, there was some evidence of malfunction or vapor loss in eighty-eight percent of the visits to vacuum assist stations. There were, however, four locations which were partially inoperative during the entire period of the study. In these cases, retrofits expected during the planning stages of the project were not accomplished. If these locations are not included in the evaluation, the proportion of visits to vacuum assist stations where hydrocarbon losses or malfunctions were observed becomes eighty-four percent. There were no hydrocarbon losses or equipment malfunctions observed at one location equipped with a direct flame afterburner unit not incorporating intermediate vapor hold-up in a carbon bed or in a vapor holder. Excessive vapors may have been consumed by this unit because of nearly continuous operation possibly resulting from piping leaks. (See Table V).

Vapor capture effectiveness at the nozzle-fill tube interface did not appear to be affected by "self-serve" gasoline delivery. There were very few instances of gasoline spillage during delivery operations. Activated carbon adsorption bed vents appeared to be a minor source of hydrocarbon losses.

No data on quantitative control efficiencies of complete vapor recovery systems were obtained during this study nor can direct inferences be drawn on efficiencies from the information presented.

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1. INTRODUCTION

In the prevention of photochemical oxidant air pollution, control of gasoline vapor displaced during retail marketing operations has been recognized as an important measure. In a pioneering effort, the San Diego Air Pollution Control District promulgated in 1972 regulations requiring the use of vapor recovery systems at gasoline filling stations, to minimize the escape of hydrocarbon vapors to the atmosphere during the delivery of gasoline to individual vehicles. Several manufacturers have devised and marketed systems for this purpose. They are currently in use in the San Diego and San Francisco areas and to a lesser degree in other metropolitan areas of the United States. These are known as Stage II controls although they can be used to assist in controlling vapors during bulk delivery of gasoline to the service station (Stage I control).

As a special task under EPA Contract 68-02-1405, PES has conducted a study of the effectiveness and operational reliability of new and modified vapor-control systems in San Diego County. The objective was to investigate new systems and those which had been modified since the TRW study of 1974*. Most new and modified systems which were in operation were included in the study. A large number of units were in the process of being modified and were shut down. The approach used in this study was to conduct periodic inspections of selected operating systems to determine whether the systems were in proper operating condition and were being properly utilized, and to test for observable hydrocarbon vapor losses from the equipment and from the interface between the dispensing nozzle and the vehicle fillneck during filling operations.

The San Diego County area was chosen for the study because the two principal types of service station vapor recovery equipment, vapor balance and vacuum assist, were in use and available for

*Powell, D.J. and D.E. Hasselmann. "Reliability Observations and Emission Measurements at Gasoline Transfer Vapor Recovery Systems." TRW, Inc., for EPA under Contract 68-02-0235, November 1974.

observation. In vapor balance systems, the vapor laden air from the fuel tank of the vehicle is displaced directly (through tubing) into the vapor space of the underground storage tank. The motive force is supplied by the pressure generated by the dispensed gasoline in the vehicle tank and by the vacuum created in the undeground tank by gasoline removal. In vacuum assist systems, displaced vapors from the vehicle fuel tank are captured at the vehicle fillneck by means of an air pump or blower. In the latter type of system, excess vapors are treated in a supplementary control unit. Two types of vapor balance and five types of vacuum assist systems were in use at filling stations selected for the survey. These systems are described in Section II of this report.

This report deals primarily with Stage II vapor recovery. Although some information was gathered on Stage I, the data was not sufficient to be treated in this report. (Stage I vapor recovery deals with underground tank refilling operations, Stage II vapor recovery deals with vehicle refueling operations). Subsequent sections cover methods of investigation and equipment utilized in the study, inspection procedures, study-findings, discussion, and conclusions.

Hydrocarbon breakthrough detectors, supplied by the Environmental Protection Agency, were installed at the outlet of carbon bed adsorption units at six service stations. There were two types of detectors (described in Section III-F below) and three makes of control equipment represented. Thus, each type of detector was installed on each of the three makes of control equipment. The detectors were installed to determine whether hydrocarbon concentrations above a pre-set level in exit gases were discharged from the carbon beds.

Further study of the characteristics and performance of carbon units is to be carried out as part of the same contract. The purpose of the carbon study is to determine the capacity of the

carbon beds and effectiveness of regeneration cycles, and to indicate whether there is a build-up of residual high molecular weight hydrocarbons on the carbon beds. Carbon samples will be taken once each month for about six months and tested to determine:

1. Capacity and retentivity in adsorption of carbon tetrachloride.
2. Hydrocarbon content by thermal analysis.
3. Loading of particular hydrocarbons, by gas chromatography.
4. Bulk density.

As another subtask, costs associated with the various vapor control sytems have been determined. Information was obtained from installation contractors, station operators, oil companies, the San Diego Air Pollution Control District, and the office of the San Diego County Assessor. A final report on this subtask was submitted earlier titled "Cost Data, Vapor Recovery Systems at Service Stations" by R.J. Bryan and R.L. Norton. Information on this report is available from EPA Emissions Measurement Branch, Research Triangle Park, N.C.

II. VAPOR RECOVERY SYSTEMS

A. VAPOR-BALANCE SYSTEMS

The simplest vapor recovery systems are the vapor-balance systems, which operate on the principle of a simple exchange of materials between the vehicle tank and the service station storage tank. As liquid gasoline is withdrawn from the underground storage tank and pumped into the vehicle tank, it displaces an equivalent volume of vapor-laden air, which either enters the underground tank through a return line to replace the liquid removed or leaks to atmosphere. In principle, with tight connections, such systems might operate indefinitely without loss of hydrocarbons. Achieving such operation is difficult, however, because in practice it is difficult to obtain a tight seal between the nozzle and the fill-neck for all vehicles. Therefore, leakage at this point is frequently encountered. Figure 1 illustrates a typical balance system.

Vapor-balance systems installed by Gulf Oil Corporation and by Standard Oil Company of California at four of the twenty-four systems were the only balance systems in operation in the area during the study period.

Two different piping layouts were used for the vapor balance systems. In the first case vapor return lines were manifolded together and the vapor spaces of the underground tanks were interconnected. In the second design, only the vapor return lines serving the same grade of gasoline were manifolded with no interconnection between tanks.

B. VACUUM-ASSIST SYSTEMS

1. General

In vacuum-assist systems, a negative pressure is maintained within the vapor-return tubing, thus enhancing the capture of vapor at the nozzle-fillneck interface. This approach

is usually more effective in capturing vapor at the fillneck, provided sufficient flow of air is maintained, as compared to vapor balance systems.

Air movement, in such systems, is induced by blowers or other aspirating devices (in one of the systems suction is provided by a Venturi ejector operated by compressed air). In all vacuum assisted systems the quantity of vapor-air mixture returned exceeds the amount of gasoline delivered, i.e. the V/L ratio exceeds 1, thus requiring the processing of the excess vapor mixture to capture or destroy the hydrocarbons contained therein. In various systems, this processing is achieved by condensation, by burning with or without a catalyst, or by some combination of these methods. Intermittant accumulation of hydrocarbons by use of vapor holders or activated carbon is sometimes utilized.

Reliability and malfunctioning of the mechanical and electrical components are potential problems associated with vacuum assist systems. Specific problems include: leaks at seals, fittings, and vents; mechanical failure of components; improper sequencing; loss of carbon sorbency; poor combustion conditions in afterburners; and failure to follow operating or maintenance procedures.

Vacuum-assist systems marketed by five manufacturers were investigated in this study. For convenience, in this report, the different designs studied will be identified by the names of the manufacturers. It should be noted that the manufacturer of the vacuum assist systems is not usually responsible for full service installations which include piping, electrical hook-up, P-V valves, nozzles, etc.

Illustrations shown are examples of the vapor recovery systems. The vendors will usually carry a line of varying sized units.

2. Intermark Compression Refrigeration Condensation (CRC) System

A system developed by Intermark Industries, Inc., depends upon compression and refrigeration to condense hydrocarbons from the gas stream. A unique feature is a surge tank for containing the air-hydrocarbon vapor until an appropriate amount for processing is accumulated.

Figure 2 is a schematic diagram of the Intermark Mark I system. Vapors are drawn from the nozzle by a blower; a tee provides for the return of vapor to the underground tank. Vapor laden air passing through the blower bubbles through liquid gasoline in the surge tank. This causes further gasoline evaporation if the air is not initially saturated. Within the tank, a flexible bladder moves a switch, activating the compressor of a refrigeration unit when a predetermined position is reached. Air and vapor are withdrawn from the surge tank, compressed and refrigerated, condensing the hydrocarbons to a liquid which is returned to the surge tank and thence to the storage tank.

Figure 2 also indicates the locations of points (x) which were monitored by the study team to detect possible leakage of hydrocarbon vapors, and the location of a pressure tap (p) which was installed to permit checking the bladder tank pressure at which the compressor was activated. New features since the TRW study were the addition of a vapor flow control valve and use of a different model compressor.

3. Process Products Refrigeration/Adsorption System

A system developed by Process Products, Inc. processes the vapor-laden air, first by condensation, then by adsorption. Figure 3 shows a schematic diagram of this system. Vapor-laden air is collected by means of a blower, located at the pump island, and is delivered to the underground storage

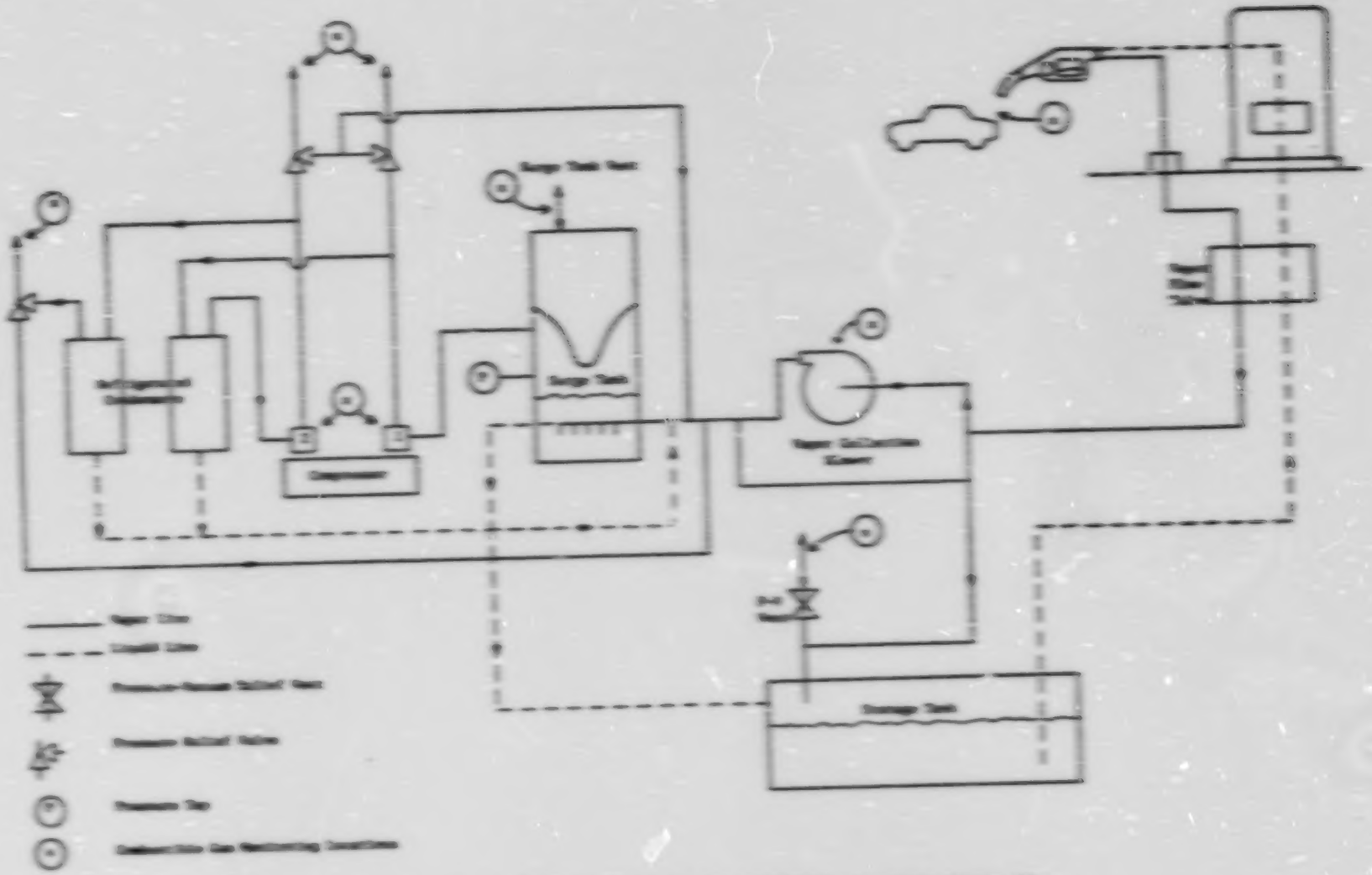


Figure 2. SCHEMATIC DIAGRAM OF [illegible] SYSTEM [illegible]

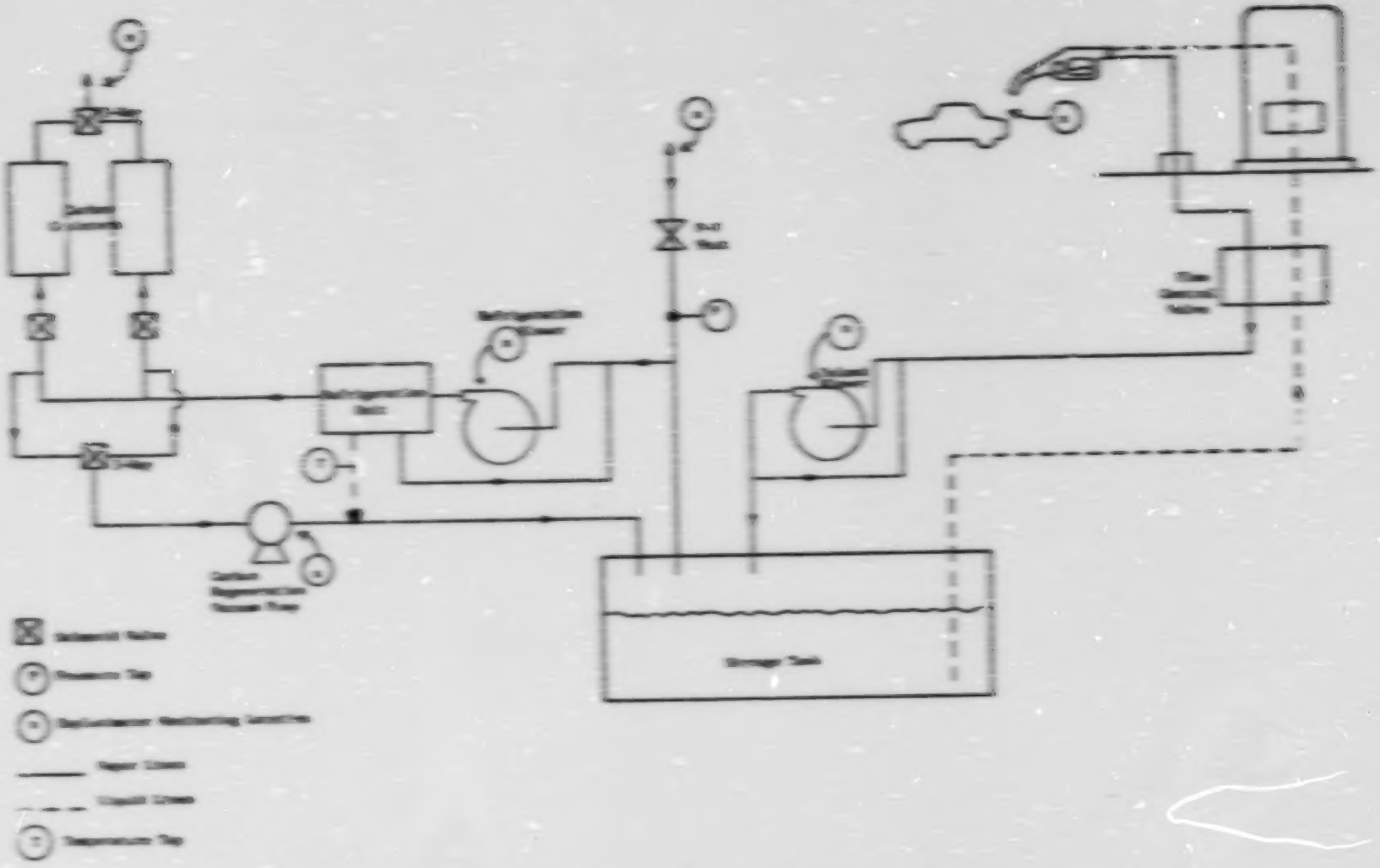


Figure 1. SCHEMATIC DIAGRAM OF PROCESS PRODUCTS SYSTEM

tank. When the pressure in the tank reaches a predetermined value, a second blower is activated, moving air from the tank to a refrigeration unit, from which condensate flows back to the storage tank. As shown in the schematic this model incorporates partial recirculation through the refrigeration unit. The air then passes through carbon beds, which remove much of the remaining hydrocarbons before venting to the atmosphere. When the tank pressure is reduced to another predetermined value, or after thirty minutes, the refrigeration blower is deactivated.

To regenerate the carbon, a pump evacuates the canister (one at a time), delivering the air and desorbed vapors to the air space of the storage tank. This operation is performed automatically, 30 minutes after the refrigeration blower is deactivated.

Figure 3 also indicates the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, and the locations of pressure and temperature taps installed to determine tank pressure and condensate temperature. Information provided by the manufacturer indicated that the blower serving the refrigeration unit should be automatically activated when the tank pressure (gauge) reaches one inch of water, and deactivated when tank pressure falls to one half inch.

The condensate temperature is expected to be about 20°F. Modifications to this system since the TRW study consist of the replacement of the belt-driven blower by a direct drive blower and the routing of the refrigerated gas stream directly through the carbon canisters to the atmosphere instead of recycling to the underground tank.

4. Clean Air Engineering Adsorption/Incineration System

A system developed by Clean Air Engineering Inc. employs carbon canisters to adsorb vapors and direct flame burners to dispose of the hydrocarbons released when the sorbent is regenerated. A schematic diagram of the clean air model 5000B is shown in Figure 4. Vapor-laden air is collected by means of a blower and delivered to the processing unit. A tee connector ahead of the blower provides for drainage of any entrained liquid back to the storage tank. A second tee after the blower directs part of the vapor-laden air to the underground tank and the remainder to the processing unit. In the processing unit, activated carbon adsorbs hydrocarbons and the stripped air is vented. After 30 seconds of operation in this mode, a second blower is activated, which draws fresh air through the carbon canisters, delivering the desorbed hydrocarbons to a set of burners, where they are destroyed. Two stages of combustion are employed; the burning continues until the rate of desorption becomes too low to support combustion at either stage, at which time the second blower is deactivated.

Figure 4 also shows the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, as well as the location of a pressure tap which was installed to permit checking pressures in the burner manifold. According to the manufacturer, this pressure should normally be maintained at 5 to 5 1/2 inches of water. The modification to this system since the TRW study consists of the replacement of the gasoline engine (which burned the vapors) by a direct-flame, two-stage burner.

5. Environics Adsorption/Catalytic Incineration System

A system developed by Environics, Inc. employs carbon canisters to adsorb vapors and a catalytic reactor to burn the hydrocarbons released when the sorbent is regenerated. A

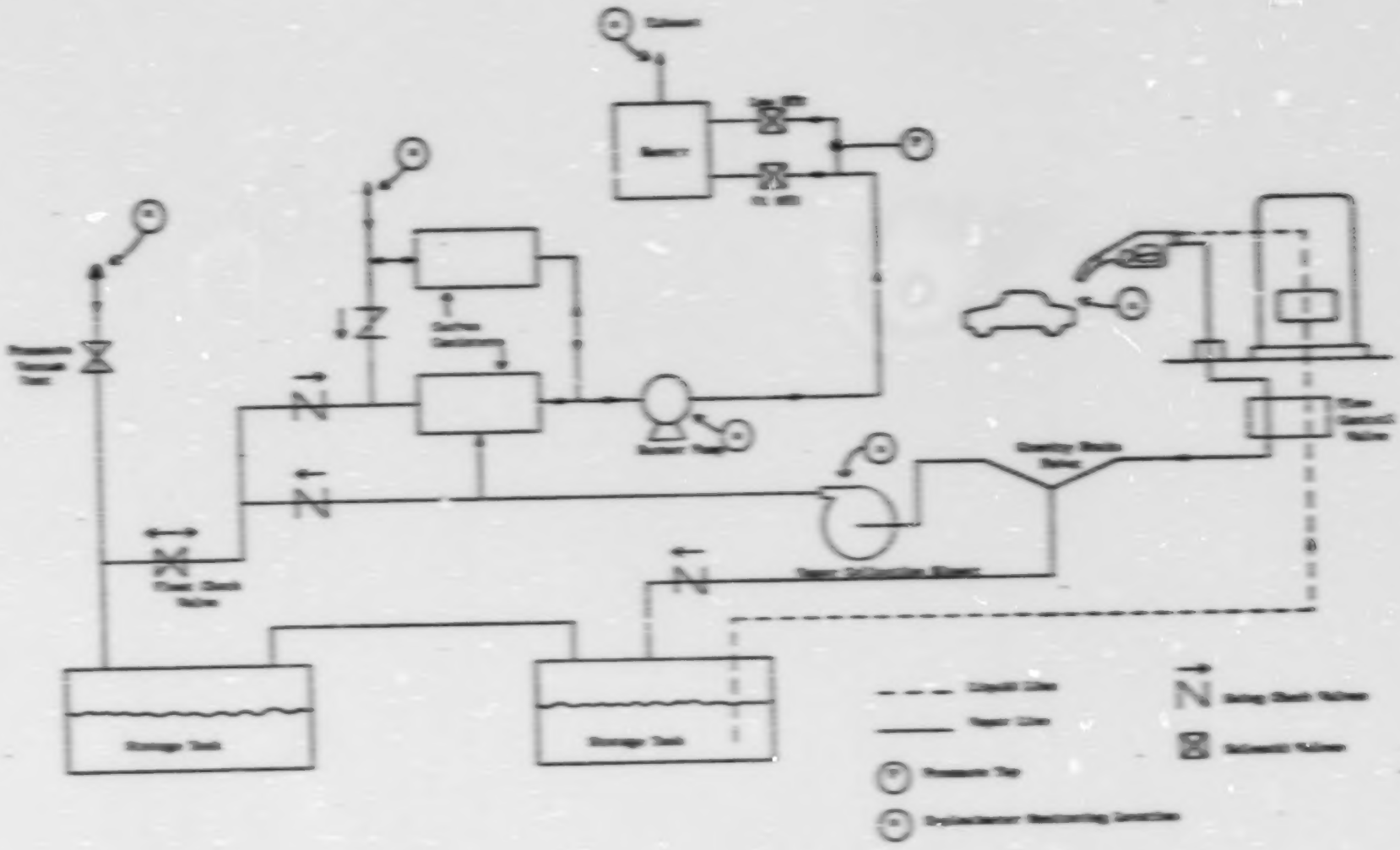


Figure 4. SCHEMATIC DIAGRAM OF CLEAN AIR ENGINEERING SYSTEM
(Model 5030B)

schematic diagram of the Environics Model A-3000 is shown in Figure 5. Vapor-laden air is collected by means of a blower and delivered to the underground tank and to the processing unit. (Entrained liquid is trapped and drained to the storage tank).

In the processing unit, activated carbon adsorbs hydrocarbons and the stripped air is vented.

At regular intervals of about thirty minutes, one of two carbon canisters is individually flushed with clean air which carries desorbed vapors to the reactor after dilution with additional air, while the other canister is on stream. Cycling is accomplished by a system of solenoid values.

The reactor is designed to operate at temperatures between 900° and 1200°F. Preheating with an electric element initiates combustion when the unit is activated. When the feed becomes so lean that a temperature of 900°F cannot be maintained, the flushing is terminated. A temperature override switch is also provided, which deactivates the unit in case of overheating; this is set for a limiting temperature of 1300°F.

Figure 5 also shows the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, as well as the locations of pressure and temperature taps installed to facilitate observation of the operating parameters of the system. According to information supplied by the manufacturer, a pressure-activated switch allowing the vapor-laden air to enter the carbon canisters should open when the pressure reaches 3 1/2 inches of water. The modifications to this system since the TRW study consist of: 1) the addition of a vapor flow control valve, 2) the rerouting of most of the vapors to the underground tank, and 3) the addition of a thermal overload switch to the reactor.

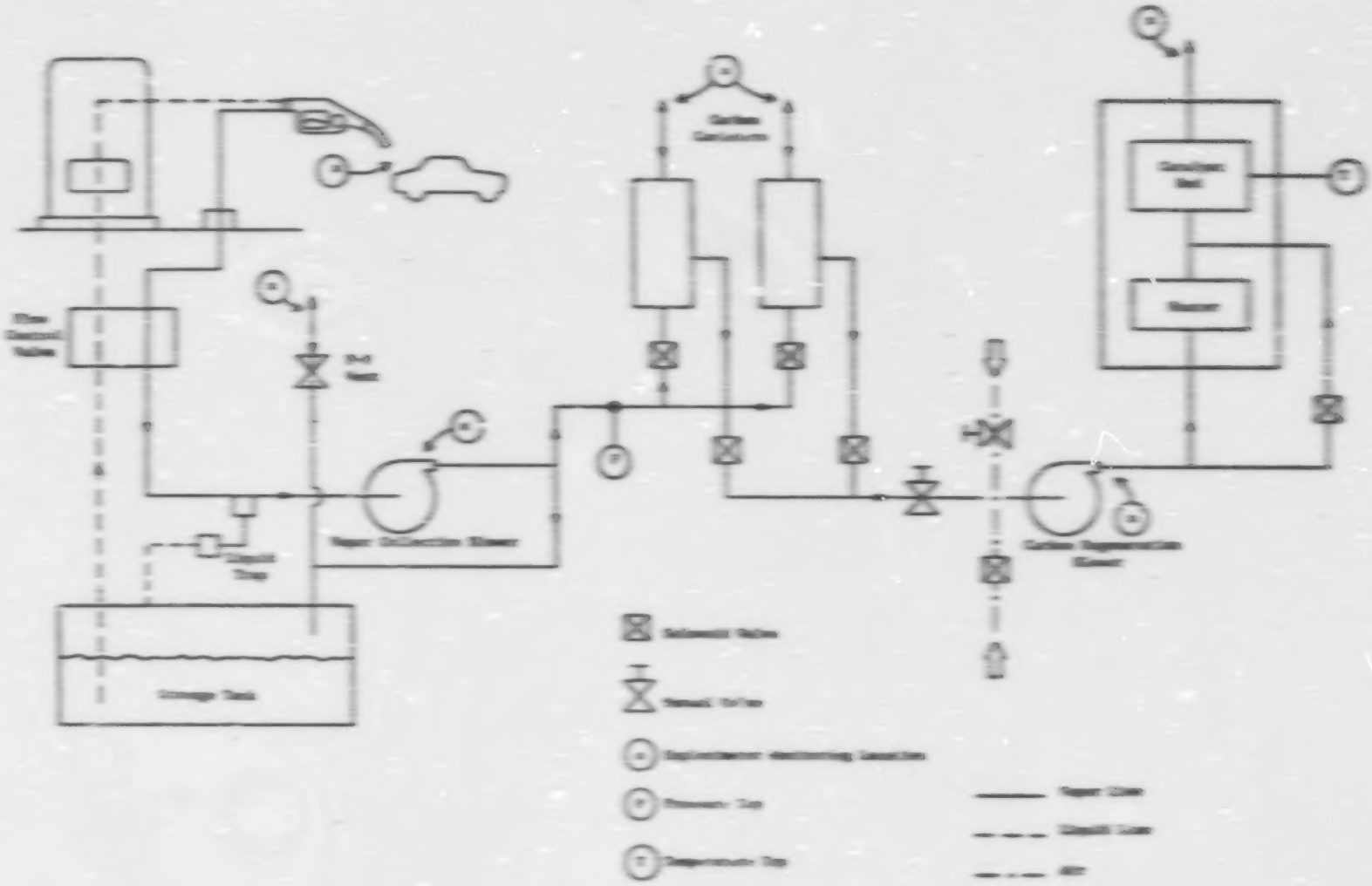


Figure 5. SCHEMATIC DIAGRAM OF ENGINEERING SYSTEM (MODEL A-3000)

6. The Hirt System

A system developed by Hirt Combustion Engineers employs an air-actuated ejector to maintain negative pressure in the underground storage tank and burners to destroy the hydrocarbons which are carried through the system. A schematic diagram is shown in Figure 6.

Flow of compressed air is initiated whenever the absolute pressure (for clarity of discussion, performance in terms of absolute pressures is used; in practice, differential pressure actuators are used) in the tank rises above a predetermined absolute value. The air flows to a set of burners, entraining vapor-laden air from the tank. Combustion is initiated by a pilot light, fueled by propane; an alarm system notifies the station operator in case the pilot flame should fail. The compressed air flow is automatically halted when the absolute pressure in the underground tank falls below a preset value.

Figure 6 also shows the locations of points monitored by the study team to detect possible leakage of hydrocarbon vapors, as well as the locations of existing pressure taps which were used to check on pressures in the storage tank and in the compressed air system. In the single system observed in this study, the preset levels were -0.58 inches of water to activate compressed air flow, and -0.61 inches to deactivate it. This system was designed and built since the TRW study.

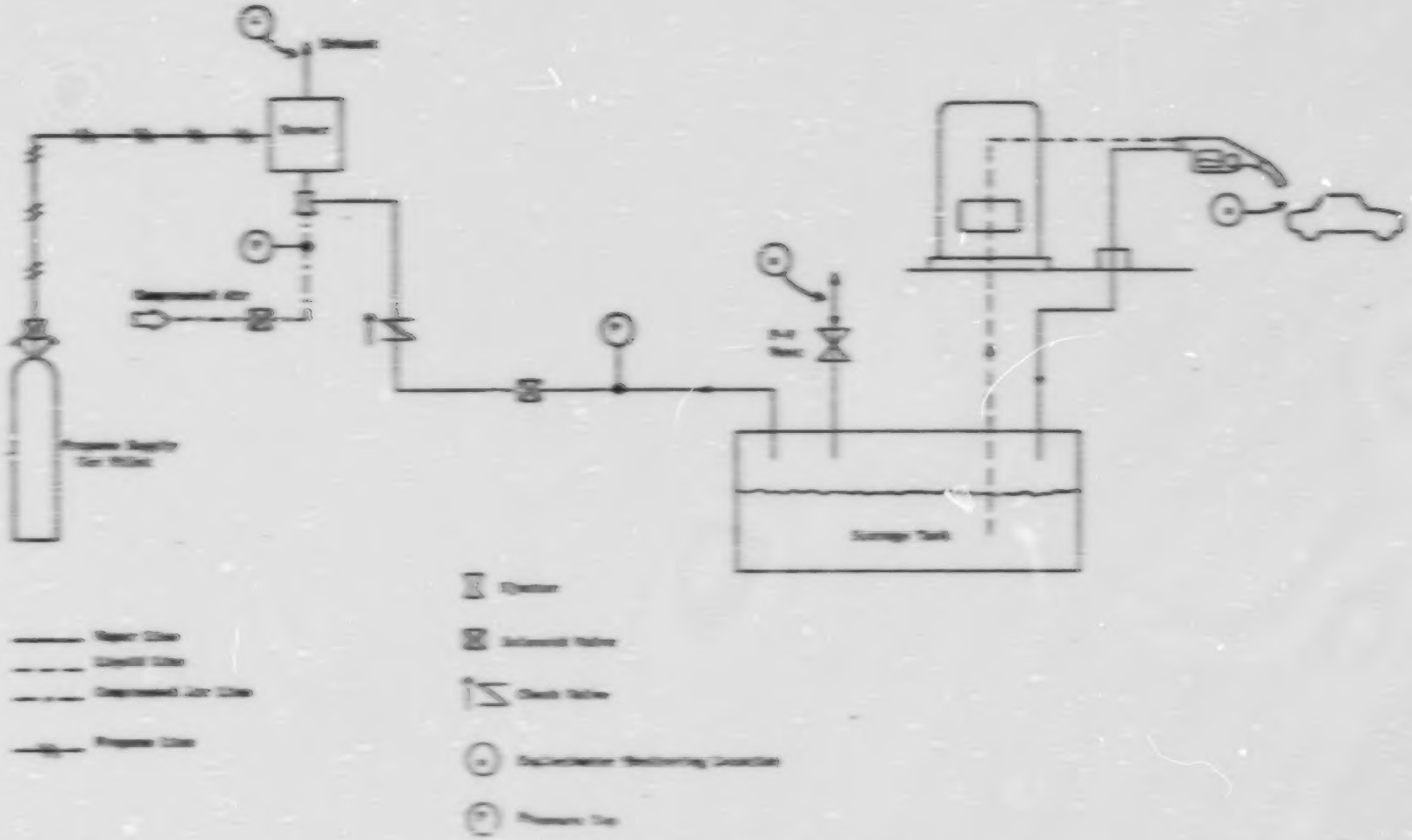


Figure 6. SCHEMATIC DIAGRAM OF FUEL SYSTEM

III. METHODS AND EQUIPMENT

A. THE STUDY PLAN

The basic study plan was to undertake repeated inspection of the operational status of vapor-recovery systems and components at a selected group of gasoline filling stations, to identify reliability problems and to monitor parameters which affect vapor control at these stations. Using a combustible gas indicator the frequency and approximate magnitude of vapor losses were to be checked at delivery nozzles during vehicle service and at potential leakage points associated with the various recovery systems. As discussed below, there were several criteria used for inclusion of stations in the study, which included selection from a list of stations which had permits to operate as supplied by San Diego County.

Inspection procedures were developed taking into account the configuration of the vapor recovery system and were designed for one visit per station per week. These visits were performed on varying days and at varying times during the day (inspection visits made only during daylight hours).

B. STATION SELECTION

Information necessary for selecting the stations to be studied, as well as for designing inspection forms, checklists and other program elements, was obtained at meetings and interviews with representatives of the vapor recovery system manufacturing companies, the San Diego County Air Pollution Control District, the U.S. Environmental Protection Agency, and others. The original selection plan called for five stations for each of the manufacturers or types of control systems represented in the general study protocol. These stations were to have throughputs of at least 30,000 gallons per month. In order to have sufficient repeat visits, not all operating

systems of some manufacturers were included. For other manufacturers where the available number of stations was small, some units which were expected to be in operation soon were included. It was not possible to meet the 30,000 gallons/month minimum criteria in all cases, but most of those which had lower monthly throughputs, did dispense high volumes at certain times of day, associated with shift changes. These stations were non-commercial, self-service stations operated by government agencies or local enterprises with large vehicle fleet operations, such as Stations 16 and 21, of the California Highway Patrol; Station 15, the U.S. Postal Service; and Station 3, for Terminix Pest Control. Station 22 was included because it was the only available example of the Hirt Combustion Engineers vapor control system. Table I lists the stations selected, the type of control system used, and other pertinent information.

As shown in Table I, monthly throughput observed during the study ranged from 4,600 to 212,500 gallons but most of the stations ranged between 15,000 and 90,000. The number of vapor-control units representing each type of system was either 4 or 5, except for the single Hirt system installation.

C. INSPECTION FORMS

Using information obtained in the preliminary meetings and interviews, the study team developed an inspection strategy for each type of control system, involving determination of the operational status of the unit, observation of the operational sequence, and tests for hydrocarbon leakage at various appropriate points. For each type of system, an inspection form was designed for recording information to be acquired on each inspection visit. These forms are exhibited in Appendix A; they served as a check list of inspection points, as well as a field record.

Table 1. FILLING STATIONS SELECTED FOR STUDY*

Station No.	Brand Name	Location	No. of Pumps	Throughput, Gallons/mo.	Locality
1	[illegible]	Standard	9	46,700	Clairemont, and Clairemont Mesa, San Diego
2	Chevron	U.S. Navy	4	35,500	Pt. Loma Road, San Diego
3	Definance	Texaco	2	4,600	Pickens and Harney, San Diego
4	Chevron	Standard	6	87,100	Thermopolis Blvd., San Diego
5	[illegible]	Unio	8	35,100	Spring St., San Diego
6	[illegible]	Standard	10	46,500	Baltimore and Lake Murray, La Mesa
7	Definance	Texaco	8	36,400	Baltimore and Fletcher Parkway, La Mesa
8	Chevron	Sears	8	72,300	Johnson and Fletcher Parkway, El Cajon
9	[illegible]	Standard	12	97,400	Johnson Ave., El Cajon
10	[illegible]	Mobil	8	65,900	University and College, San Diego
11	Chevron	Union	16	112,500	30th and Highland, National City
12	[illegible]	Mobil	6	38,000	University and Ohio, San Diego
13	[illegible]	Mobil	6	51,000	University and Boundary, San Diego
14	[illegible]	Mobil	10	61,000	Texas and El Cajon, San Diego
15	Definance	Rio Grande	2	16,200	Midway Drive, San Diego
16	Chevron	Highway Patrol	2	24,100	Pacific Highway, San Diego
17	Chevron	Dept. of Navy		n.a.	Linda Vista Rd., San Diego
18	[illegible]	Standard	10	36,500	Friars and Frazee, San Diego
19	Chevron	Standard	12	103,200	Carmel Valley Rd., San Diego
20	Chevron	Unio	10	63,300	Santa Fe Dr., Encinitas
21	Chevron	Highway Patrol	2	16,300	Oceanside Blvd., Oceanside
22	Mint	Phillips	6	72,500	Mission and Canyon, Oceanside
23	Definance	Phillips	6	48,200	Elm and Harding, Carlsbad
24	Definance	Unio	12	85,000	4th and Robinson, San Diego

*Not all the stations had completed installations when the study started, but completion was expected soon. The opening of Stations 19 and 20 were not completed during the study. Station 17 was dropped when it became apparent that the monthly throughput was substantially less than had been expected.

D. INSPECTION PROCEDURE

On each inspection visit, the study team announced their presence to the station manager and inquired about the operational status and recent experience with the control system. If the unit was operational, an operation sequence check was performed, and relevant pressures and temperatures were measured and recorded. Serial numbers of component machinery (blowers, compressors, pumps, refrigeration units) were recorded and any replacements noted. Combustible vapor readings were taken at all prescribed locations. In most cases, a number of vehicle tank fillings were monitored for hydrocarbon vapor losses, using a combustible gas meter. The probe tip was moved in a circular motion around the nozzle-filler tube interface at a distance of one half inch. Information on the station's throughput of gasoline was recorded, and the operator's comments collected, before terminating the inspection.

E. EVALUATING OPERATIONAL STATUS

On each visit to each station, the study team was required to determine whether the vapor control system was operating in accord with design specifications. This was done by observing the performance of the various elements of the system to answer the questions listed under "Operational Sequence Check" on the corresponding inspection form (Appendix A).

For each of the vacuum-assist systems, pressures within the system were measured at strategically located pressure taps as indicated in the schematic diagrams, Figures 2 to 6. Magnehelic gauges having a sensitivity of 0.01 inch of water were used, with self-sealing, quick-connecting Imperial Eastman fittings. With two of the systems, temperatures were also determined. For this purpose thermocouples were used, and the potentials generated were measured with a portable potentiometer (Thermo-Electric Co., Model 31101, "Minimite").

F. DETECTION OF HYDROCARBON VAPOR LEAKAGE

An important aspect of the inspections was the detection of leaks. For this purpose the study team used a Combustible Gas Analyzer, Model 55P, manufactured by Bacharach Instrument Co., with scales reading from 0 to 1000 ppm and from 0 to 1.0 relative to the lower explosive limit (L.E.L.). Readings were taken at the points indicated in Figure 1 through 6 on each visit to each station, and at the fillneck of the vehicle tank for each of the several cars served by the station on each visit.

For studying the effectiveness of the carbon adsorption systems (in removing hydrocarbons from the exhaust air), hydrocarbon detectors were installed at two stations for each of the three vapor-control systems (Process Products, Clean Air Engineering, Environics) which incorporate adsorption. These devices were of two designs. The first, or "latching" type triggers a timer whenever the hydrocarbon concentration exceeds the set point, 1.2 percent or 12,000 ppm, V/V. The second, or "non-latching" type similarly triggers a timer at the set-point but, unlike the first, the timer is stopped whenever the hydrocarbon concentration subsequently falls below the set-point. The timers were checked, readings recorded, and instruments re-set if necessary at each inspection of the six selected stations.

There were several purposes for installation of the hydrocarbon detectors: 1) to indicate whether any hydrocarbon leakage above the set point occurred during normal operation, 2) to indicate whether the carbon beds saturate before regeneration, and 3) to indicate whether high molecular weight hydrocarbons build up on the carbon beds and reduce capacity.

6. PERFORMANCE EVALUATION

For purposes of performance evaluation, effectiveness of vapor collection at the vehicle fuel tank was considered separately from performance of the vapor recovery system itself. That is, it would be possible for a system to be nearly completely effective in vapor collection and yet perform poorly in processing these vapors so as to prevent their discharge to atmosphere. For purposes of evaluating reliability of the processing equipment the term malfunction is defined to include both demonstrable malfunction of a component or evidence of a hydrocarbon loss exceeding 100 ppm (the minimum detectable concentration) using a combustible gas analyzer.

IV. RESULTS AND DISCUSSION

A. GENERAL

During the study, 140 inspection visits were made to the stations listed in Table I, and 506 vehicle fillings monitored. The data on vehicle fillings are shown in Appendix B. In the great majority (88 percent) of visits to vacuum assist stations, some malfunction was detected; in only 14 of 115 visits were the vacuum assist systems found to be operating in accord with the manufacturer's specifications and free from hydrocarbon vapor losses. If the stations which did not operate during the entire study period are excluded, malfunctions were detected in 84 percent of the visits (14 of 89 visits).

Since the magnitude of the losses could not be determined, the results of the study are here presented and discussed in terms of frequency of occurrence of combustible vapor readings relative to certain benchmarks, namely, 100 ppm hydrocarbon (lower scale of the indicator); 0.1 LEL (one tenth of the lower explosive limit, as shown on the upper scale of the indicator); and 0.6 LEL. The 0.1 LEL criterion is based upon an EPA finding which stated when there were no leaks at the nozzle/fillneck interface, hydrocarbon concentrations did not exceed 0.1 LEL. The 0.6 LEL criterion is the upper limit allowed by the San Diego County Air Pollution Control District.

Table II shows for each type of control system, the frequency of inspection, the number and percent of the visits on which the control system was found to be operating correctly and without leaks, the number of vehicle fillings observed and the number and percent of vehicle fillings in which hydrocarbon vapors were not detectable. The four vapor-balance systems, having far fewer mechanical components, evidenced no equipment failures, and since no potential leakage points were accessible for testing, no instances of faulty operation were observed. However, the vacuum-assist systems, when operating correctly, were much more effective in controlling vapor losses at the nozzle.

Table II. SUMMARY OF INSPECTIONS

Control System	% Daily	No. of Visits	Correct Operation[a] No.	%	Vehicle Refuelings No. of No. of Vehicle Fillings	No. with No HC Loss[b]	%
Vapor-balance	4	25	25	100[c]	105	21	20
Intermark	4 (2)[d]	25 (19)	0	0	65 (34)	46	54(66)
Process Products	5 (2)	35 (15)	4	11 (27)	120 (57)	67 (40)	56(70)
Clean Air Eng.	4	25	3	12	104	77	74
Environtics	5	23	1	4	78	24	31
Hirt	1	6	6	100[e]	14	10	71
All Vacuum Systems	19 (15)	115 (88)	14	12 (16)	421 (333)	234(206)	56(64)
All Systems	23 (14)	140 (114)	39	28 (34)	526(405)	265(227)	49(53)

a. For this tabulation "Correct Operation" indicates that the operator's sequence follows the manufacturer's specifications and that no collectible vapors (hydrocarbon losses) could be detected at preselected check points.

b. This value indicates the number of fillings observed in which hydrocarbon losses could not be detected; that is, the collectible gas analyzer registered no vapor concentration above its lower detectable limits (100 ppm)

c. At the stations with vapor-balance system, operated by Gulf Oil Corporation, clear plastic tubing was installed in the vapor return lines at the beginning of the study. These were installed to permit visual inspection of the lines for possible blockage by accumulated liquid gasoline. After about three weeks this tubing was replaced by ordinary opaque tubing, when it was found that the clear plastic deteriorated rapidly and was easily kinked, causing unsatisfactory operations of the system. It should be noted that when the clear plastic tubing was installed, vapors could be seen to easily bubble through any liquid blockage that did occur.

d. Although the Hirt system was always operational, the observed frequency of cycling--about once per minute--suggests that air leaks into the system may have been triggering operation more often than satisfactory vapor loss control would require.

e. Numbers in parentheses denote totals of stations not operating during the study period awaiting retrofit per switch.

Total system efficiency is not a direct function of nozzle losses as the excess air/vapor ingested and the vapor processing unit efficiency must also be considered.

D. SYSTEM MALFUNCTIONS

During the 115 inspection visits to stations with vacuum assist systems, 174 instances of specific malfunctions were observed, as listed in Table III. The only evidence of malfunction was, in 130 instances, observation of hydrocarbon losses at one of the testing locations specified on the inspection forms. Such malfunctions did not necessarily interfere with the continued operation of the system, but did impair the effectiveness of vapor control. In 36 instances, the systems were inoperable or were, for other reasons, not in operation at the time of the inspection visit. The distribution of these 36 malfunctions is shown in Table IV. In only 9 of these instances (8 percent of the visits) were equipment failures the immediate cause of the shutdown. Another 15 instances were due to failure of station personnel to activate either the vapor collection device or the entire system. In the remaining instances, disconnected vacuum hoses were responsible 8 times, and automatic shutdown due to overheating of a catalyst reactor occurred 4 times. Thus, although the control equipment was out of operation on approximately one third of all the inspection visits, only one third of these instances (13, or 11 percent of the visits) were attributable to system failures. In another 8 instances, the systems were operable but an indication of a malfunction was described by the station operator (4 instances of excessive cycling resulting in extremely high electric bills, 4 instances of poor ITT valve adjustment).

On 14 other inspection visits the systems were inoperable due to the fact that equipment installation had not been completed. Of these visits, 7 occurred at one station where the processing unit had been disconnected because of a fire and not reconnected. The

Table III. FREQUENCY OF OCCURRENCE OF SPECIFIC MALFUNCTIONS AT VACUUM ASSIST STATIONS

Hydrocarbons observed at blowers and pumps	33
Hydrocarbons observed at underground tank vent	25
Hydrocarbons observed during burner ignition	19
Hydrocarbons observed at surge tank vent	13
Hydrocarbons observed at carbon canister vent	9
Unit turned off	8
Vacuum hoses disconnected	8
Hydrocarbons observed at reactor vent	7
Hydrocarbons observed at condenser relief vent	7
Island blower not on	7
Hydrocarbons observed at piping connection	6
Hydrocarbons observed at compressor	6
Hydrocarbons observed at compressor relief vents	5
Poor ITT valve adjustment	4
Unit off due to temperature override	4
Broken blower belt	4
Constant cycling by unit controls	4
Blower motor failure	3
Unit down due to compressor failure	2
Total	174

Table IV. FREQUENCY OF CAUSES OF FAILURE TO OPERATE AT VACUUM ASSIST SYSTEMS

1.	Unit turned off	8
2.	Vacuum hoses disconnected	8
3.	Vapor-collection blower turned off	7
4.	Broken blower belt	4
5.	Automatic temperature cutoff	4
6.	Blower motor failure	3
7.	Compressor failure	2
	Total	36

other 7 instances were noted at another station where installation of a new compressor had not been completed. Table V lists the observed malfunctions by manufacturer.

Hydrocarbon losses, evidenced by testing with the combustible gas analyzer, were predominantly associated with, or caused by equipment failure, as shown in Table VI. Approximately two thirds of the observations appeared to be attributable to such failures. The cause of hydrocarbon observations at the underground tank vent could be attributed to bulk drops in only 10 percent of these occurrances. Other causes were incomplete or faulty installation, as well as improper adjustment or failure to use the equipment properly. About twenty percent of the hydrocarbon loss observations occurred during normal system operation. These included small losses at the Clean Air Engineering burners prior to ignition, and at the reactor vent of the Environics system. Such losses ordinarily do not continue for any protracted period.

C. MEASURED OPERATIONAL PARAMETERS

Pressures and temperatures recorded at the taps described, for the various vacuum-assist vapor control systems, were compared with the values specified as standard by the manufacturers, as given in Section II. Notes reflecting the observations on these parameters are presented in Appendix C.

For the Intermark System, no pressures or temperatures in the CRC unit or bladder tank were specified. Pressures as high as 7.5 inches of water in the surge tank were observed when the bladder was fully distended. When the level indicator registered about one eighth of capacity, observed pressure ranged from about 0.5" to 2.0".

With the Process Products systems, only two of the stations provided useful data; the other units were inoperative most of the time, awaiting delivery of vapor collection blowers. The two operating

Table V. FREQUENCY OF OCCURRENCE OF SPECIFIC MALFUNCTION BY MANUFACTURER

ENVIRONICS - 83 visits

HC at Reactor vent -	7
HC at Carbon Canister Vent -	6
HC at Underground Tank Vent -	6
HC at Blowers and Pumps -	6
Unit Off Due To Temperature Override	4
Poor ITT Valve Adjustment -	4
Blower Motor Failure -	3
HC at Unit Piping -	2
Vacuum Lines Disconnected -	2
Unit Turned Off -	1
	41

PROCESS PRODUCTS - 35 visits

HC at Underground Tank Vent -	15
HC at Blowers and Pumps -	14
Island Blower Not on -	7
Processing Unit Not on -	6
Excessive Cycling -	4
HC at Carbon Canister Vent -	3
HC at Unit Piping -	1
	50

PROCESS PRODUCTS (St #5 and St #16 only) - 15 visits

HC at Underground Tank Vent -	5
HC at Blowers and Pumps -	4
HC at Carbon Cannister Vent -	3
Excessive Cycling -	3
	15

Table V. FREQUENCY OF OCCURRENCE OF SPECIAL MALFUNCTION BY MANUFACTURER (continued)

INTERMARK - 85 visits

HC at Surge Tank Vent -	13
HC at Blowers and Pumps -	8
HC at Condenser Relief Vent -	7
HC at Compressor -	6
Vacuum Lines Disconnected -	6
HC at Compressor Relief Vent -	5
Broken Blower Belt -	4
HC at Unit Piping	3
HC at Underground Tank Vent -	2
Compressor Failure -	2
	56

CLEAN AIR - 28 visits

HC at Burner Exhaust During Ignition	19
HC at Blowers and Pumps -	5
HC at Underground Tank Vent -	2
Unit Off -	1
	27

HIRT - 6 visits

Unit prone to vacuum leaks which cause unit to fire approximately every minute.

Table VI. FREQUENCY OF CAUSES OF HYDROCARBON LOSSES AT VACUUM ASSIST STATIONS

	Number Observed	Per Cent of Total
Malfunctions due to equipment failure	52	37.7
Malfunctions as consequence of equipment failures*	46	33.3
Malfunctions inherent to systems (i.e., hydrocarbons observed at burner ignition are usually very small and last for less than 30 seconds).	26	18.8
Malfunctions due to poor installation	6	4.4
Malfunction due to improper unit adjustment	8	5.8
Total	138	100.0

*Example:
Failure of equipment may cause underground tank pressure to increase if blowers are operating but no processing is taking place. This will forge venting and hydrocarbons will be detected at the underground vent.

units had slightly different settings, but pressures showed consistent behavior from week to week. At Station 5, the refrigeration unit was found to start at pressures ranging from 3.5 to 4.5" and to stop at pressures ranging from 0.2 to 1.0" H_2O. At Station 18, the unit started at 1.0 to 1.1" and stopped at 0.3 to 0.5" H_2O. (Manufacturer's information suggested start and stop pressures of 1" and 0.5" H_2O, respectively). The condensate temperature was measured only at Station 18 and was found to vary from 12 to 40°F (expected was about 20°F).

For the Clean Air Engineering systems, design pressure at the burner manifold was 5 to 5 1/2" w.c. Stations 16 and 21 operated consistently within this range. Station 2, for unknown reasons, operated at pressures ranging from 4" to 15", while Station 4 operated in the range of 3.2" to 3.5". The burner system at the latter station had reportedly been readjusted and the manifold pressure reduced in an attempt to control accumulation of soot in the burner.

In the Environics System, the pressure-actuated switch was expected to open at 3.5" H_2O w.c. In actual operation, the switches opened at lower pressures; 2.6" in one case, 1.6" in another. Reactor temperatures also were sometimes found outside the range (900-1200°F), expected for the automatic controls. In one case the reactor pump started when the reactor was at a temperature of 1290°F and continued running until the reactor temperature dropped to 740°F. In another, the reactor was at 848°F when the pump started, and at 760°F when the pump stopped.

In the single Hirt system installation (Station 22), the small burner and the compressed air flow were usually, but not always, activated at -0.50" H_2O; on one visit, the observed activation pressure was -0.61". The burner system was deactivated at -0.61" to -0.65". The controls for these pressures are accessible to station personnel and may occasionally have been adjusted by them.

With respect to the vacuum-assist systems as a group, it appears that the operating parameters are not consistently maintained within design limits; however, the extent to which this lack of control may adversely affect vapor control cannot be assessed from the data obtained in this study.

D. HYDROCARBON LOSSES ON FILLING VEHICLE TANKS

As indicated in Table II, no leaks were detected at the nozzle-fillneck interface in about half of the observed vehicle fillings. The actual fraction was 20 percent with vapor-balance systems, and from 31 to 74 percent with the various vacuum-assist systems, averaging 56 percent for all vacuum-assist units.

A higher proportion of no leak fills is evident if attention is directed only to occasions when the study team found on checking, that the vapor collection blower was operating. Also deleted in this consideration are the stations where the operators complained of poor vapor collection due to poor ITT valve adjustment. About one fourth of the fillings are excluded by this condition. Among those that remain, the proportion of successful control was from 71 to 89 percent with the various vacuum-assist systems, averaging 79 percent.

The proportion of successful control will, naturally be higher, also, if "successful" is defined more leniently. Although the combustible gas analyzer could not be used for a quantitative determination of vapor losses, it seems likely, on the whole, that when higher vapor concentrations are detected, they correspond to greater vapor losses. Also it is possible that vapor losses at times might be negligible, even though detectable with the analyzer.

Accordingly, Table VII lists the results of the refueling checks where hydrocarbon concentrations at the nozzle-fillneck interface were less than three different criterion levels. These were 100 ppm, 0.1 LEL, and 0.6 LEL, respectively. (For gasoline vapors,

Table VII. FREQUENCIES OF OBSERVED CONCENTRATIONS OF HYDROCARBONS AT NOZZLE-FILLNECK INTERFACE AT SELECTED VEHICLE FILLINGS*

MANUFACTURER	Number of Fillings*	Frequency below given level					
		<100 ppm		<0.1 LEL[a]		<0.6 LEL[a]	
		No.	Percent	No.	Percent	No.	Percent
Vapor Balance	105	21	20	40	38.1	45	41.8
Intermark	52	46	88.5	49	94.2	49	94.2
Process Products	57	49	86.0	51	89.5	51	89.5
Clean Air	104	76	73.1	86	82.7	89	85.6
Environics	28	20	71.4	23	82.1	23	82.1
Hirt	14	10	71.4	13	92.9	13	92.9
All Vacuum Systems	255	201	78.8	222	87.1	225	88.2
All Systems	361	222	61.7	262	72.7	268	74.4

* Fillings when vapor collection system of nozzle was operating correctly

a. LEL: Lower explosive limit

the lower explosive limit is approximately 1.2 percent by volume, or 12,000 ppm, V/V.) These figures refer only to those fillings in which the vapor collection system, at the nozzle, was operating as stated above. They show that, of 268 cases with concentrations below 0.6 LEL, 262 or only six less, were also below 0.1 LEL. The number of cases with concentrations below 100 ppm, however, dropped to 222.

Judged at the 0.1 LEL criterion level, as Table VII shows, the vapor-balance systems are far less effective than vacuum-assist systems in capturing vapors during the filling of vehicle tanks. Thirty-eight percent of the fillings with vapor-balance systems were below this level while the corresponding proportion for various vacuum-assist systems, when operating properly, was from 82 to 94 percent.

E. EFFECTIVENESS OF SYSTEMS WHEN OPERATING OPTIMALLY

Since both system malfunctions and operator inattention can prevent vapor-control systems from operating at full efficiency, it is of interest to examine the study data to determine what degree of effectiveness can be observed at those stations where these problems were least apparent. Table VIII shows, for each type of system, the record of successful capture of vapors at the nozzle using three different criterion levels, for the single station having the best record.

With the vapor-balance system, the best record of capture at the 0.6 LEL criterion level was slightly over 50 percent. With vacuum-assist systems, however, four of the five systems demonstrated better than 98 percent success in limiting nozzle losses to the 0.6 LEL criterion level.

Table VIII. DEGREE OF CONTROL ACHIEVED WITH VAPOR-CONTROL STATIONS OPERATING OPTIMALLY

System	Station[a] I.D. No.	No. of Fillings Observed	Tests showing less than					
			100 ppm		0.1 LEL		0.6 LEL	
			No.	%	No.	%	No.	%
Vapor-balance	6	29	10	34	13	45	15	52
Intermark	11	37	34	92	35	95	36	97
Process Products	5	24	23	96	23	96	23	96
Clean Air Eng.	21	19	18	95	19	100	19	100
Environics	3	8	5	63	6	75	6	75
Hirt	22	14	10	70	11	77	14	100

a. Station showing the highest proportion of reliable operation (fewest malfunctions or hydrocarbon leaks) during the study period.

F. EFFECT OF NOZZLE TYPE ON VAPOR LOSSES (WITH VAPOR-BALANCE SYSTEMS)

An insight into the possible importance of seemingly minor details of system construction was fortuitously furnished as the result of a system change which occurred during the study. About three weeks after the beginning of the study, many of the original nozzles of the vapor balance systems were replaced by new nozzles. The new design incorporated a metal disc and Teflon seat, a device intended to provide an improved seal between the nozzle and the fillneck while avoiding undue stress on the rubber boot sheathing the nozzle. Both were manufactured by the same firm.

A comparison of the results obtained before and after the change shows clearly that the performance of the new nozzles was inferior to that of the old. The results are shown in Table IX. With the original nozzles, vapor losses were detected in slightly more than half the fillings (55 percent); with the new nozzles, the proportion rose to over 90 percent. With the original nozzles, fewer than one fourth of the losses (23 percent) reached the 0.6 LEL criterion; with the new nozzles, more than three quarters (78 percent) did so.

G. EFFECT OF ATTENDANT SERVICE VS. SELF-SERVICE ON VAPOR LOSSES

Several stations included in the study permitted customers to use the pumps to fill their own vehicle tanks. Table X shows, for each type of vapor control system, a comparison of the vapor loss experience in such stations with the experience where service was performed by attendants; the data used in compiling the table are taken only from those inspection visits on which the vacuum system was operating satisfactorily. For Intermark and Clean Air Engineering control systems, vapor losses were observed in a smaller proportion of fillings at self-service stations than at other stations. For Environics and vapor-balance systems, the reverse was true.

Table IX. FREQUENCIES OF OBSERVED CONCENTRATIONS OF HYDROCARBONS AT NOZZLE-FILLNECK INTERFACE EXCEEDING VARIOUS CRITERION VALUES, WITH DIFFERENT NOZZLES (VAPOR-BALANCE SYSTEMS)

Nozzles[a]	Number of Fillings	Frequency of Exceeding Level					
		100 ppm		0.1 LEL[b]		0.6 LEL[b]	
		No.	Percent	No.	Percent	No.	Percent
Original	31	17	55	9	29	7	23
Replacement	74	67	91	59	80	54	73

a. The original nozzles were OPW Model 70W
the replacements were OPW Model 75P

b. LEL: Lower explosive limit

Table X. VAPOR LOSSES OBSERVED AT SELF-SERVICE AND ATTENDANT-SERVICE STATIONS

Control System	Self-Service			Attendant-Service		
	Number of Fillings	Losses[a] Observed	Per Cent	Number of Fillings	Losses[a] Observed	Per Cent
Intermark	37	3	8	15	3	20
Clean Air Eng.	48	9	19	56	17	30
Environics	9	4	44	19	4	21
Vacuum-Assist Subtotal	94	16	17	90	24	27
Vapor-Balance	45	41	91	60	43	72
All	139	57	41	150	67	44

a. Criterion is detection of hydrocarbons at 100 ppm or above

These differences are not statistically significant and, therefore, furnish no clear evidence that vapor losses at the nozzle are either more or less likely when vehicles are serviced by their drivers than when service-station attendants perform the operation.

H. EFFECT OF VEHICLE FILLNECK CONFIGURATION ON VAPOR LOSSES

In testing the vapor losses on filling vehicle tanks, it was obvious that observed losses were sometimes caused by difficulty of fitting the nozzle to the fillneck, due to unusual and inconvenient configurations of the fillneck or obstructions on the vehicle. Such occurrences were noted on the inspection records.

About forty such observations were recorded, or less than ten percent of the 506 fillings observed. A list of the vehicle models and model-years involved is given in Appendix D, which shows that automobiles of at least eleven manufacturers exhibited poor fits. Only one model (the Chevrolet Corvette) appears more than once in the list. It is therefore apparent that the problem, although a relatively minor one, is likely to be widely encountered.

I. LIQUID LOSSES IN FILLING VEHICLES

A condition known as "spitback" or "spillage", in which liquid gasoline is lost from the tank either after the nozzle is withdrawn from the vehicle fillneck or during filling, was observed by the study team in eight instances, while monitoring more than 500 vehicle fillings. This corresponds to an overall frequency of 1.6 percent. Of these 8 instances, 3 occurred with vapor-balance systems (3 in 105 fillings) and 5 with vacuum-assist systems (5 in 401 fillings).

Some station managers and operators have expressed concern about possible losses of liquid into the vapor line, from which the liquid would drain, unobserved, into the storage tank. The occurrance of spitback may appear to lend substance to these concerns in some cases. However, the study team was unable to detect such liquid losses, and no conclusion can be reached as to whether they occurred during the course of the study.

J. VAPOR LOSSES THROUGH CARBON CANISTERS

Six hydrocarbon detectors were installed at stations with vaccum-assist systems containing carbon canisters. The data are shown in Appendix E. At one station, the detector circuit was tripped shortly after installation, indicating some vapor loss i.e. in excess of 1.2% by volume. After the detector was reset on the next inspection visit, no further losses were detected. However, the vapor control system was not actually in operation during most of the time monitored. At another station, a detector having the accumulating record feature showed a total activation time of 2.6 hours during six weeks of monitoring.

The two observations described occurred at stations equipped with the Environics system. None of the other detectors showed any indications of vapor losses through the carbon canisters.

V. CONCLUSIONS

A. EFFECTIVENESS OF VAPOR RECOVERY SYSTEMS IN CAPTURING HYDROCARBON VAPORS WHEN FILLING VEHICLE TANKS

1. The study demonstrated that several vacuum-assist vapor recovery systems, when operating optimally, can be effective in capturing gasoline vapor losses at the nozzle-fillneck interface. In more than 90 percent of vehicle fillings in large retail gasoline outlets measured hydrocarbon levels near the nozzle were less than 0.5 LEL. In contrast, vapor-balance systems, at best, prevented losses in only about half of the fillings.

2. Under conditions of this study, vacuum-assist vapor recovery systems are found to be non-operational more than vapor-balance systems. When the vacuum-assist stations were not operating, the vapor balance systems were found to be more effective in control of vapors at the nozzle/fillneck interface.

3. Vapor capture is as effective, on the whole, for self-service gasoline marketing as for ordinary attendant-service.

4. The type of delivery nozzle used can have an important effect on vapor capture, especially with vapor-balance systems.

5. A small proportion (less than 10 percent during study) of vehicles served may be expected to have fillneck configurations incompatible with effective use of nozzles in use during this study.

6. In a very small proportion of fillings, liquid losses may be observed as a result of drainage from an overfilled tank ("spitback" or "spillage").

   Concern has been expressed about the possibility of liquid returning to the storage tank, unobserved, via the vapor line; the study did not evaluate this problem.

B. OPERATIONAL RELIABILITY OF VAPOR RECOVERY SYSTEMS

1. Reliability of the system in use, as shown by 740 inspection visits, varied from good to poor. Equipment failures caused shutdown of the units in less than ten percent of the inspections, although tardy delivery of components and delays in installation and maintenance resulted in non-operation of the systems in about one third of the inspection visit. (Three systems from Process Products and one from Intermark remained out of operation from this cause throughout the study.)

2. Only a few of the vacuum assist units operated reliably and without vapor leaks throughout the study. One hundred and thirty-eight instances of hydrocarbon losses from leaks in the vapor recovery systems were detected; the predominant cause of these leaks was system failure of some sort.

3. Incorrect operation or inattention by station operators was a factor in about 20 percent of the observed malfunctions.

4. Operating parameters (pressure and temperature) as observed in the inspections were frequently different from those specified by the manufacturers. It is not clear to what extent these deviations may have resulted from, or possibly caused, system malfunctions.

5. Hydrocarbon vapors were detected in the effluent air from carbon adsorption units in two of six systems tested. The significance of such losses has not been evaluated.

APPENDIX A
Inspection Forms

Time In _____ Date _____

Time Out _____ Inspector _____

INSPECTION FORM - VAPOR BALANCE SYSTEMS

Station _____

Address _____

1. Atmospheric Conditions

Temperature _____

Sky Conditions _____

Wind Speed _____

Humidity _____

2. Vehicle Fill Nozzle

Type of Nozzle _____

Make of car being filled _____

Explosimeter reading _____

Operator attempt to make a good fit Yes _____ No _____

3. Vapor Return Line

Vacuum at Nozzle Yes _____ No _____

If No, Explain (if reason is known)

Kinks or Liquid Blockage in line Yes _____ No _____

Does Operator attempt to straighten

Vehicle Fill Nozzle

_____ Type of nozzle _____

_____ Make of car being filled _____

_____ _____

_____ Explosimeter reading _____

Yes ____ No ____ Operator attempt to make a good fit Yes ____ No ____

_____ Location of gas inlet on car _____

_____ Type of nozzle _____

_____ Make of car being filled _____

_____ _____

_____ Explosimeter reading _____

Yes ____ No ____ Operator attempt to make a good fit Yes ____ No ____

_____ Location of gas inlet on car _____

_____ Type of nozzle _____

_____ Make of car being filled _____

_____ _____

_____ Explosimeter reading _____

Yes ____ No ____ Operator attempt to make a good fit Yes ____ No ____

_____ Location of gas inlet on car _____

Time In _____ Date _____

Time Out _____ Inspector _____

INSPECTION FORM - INTERMASK MARK I

Station _____

Address _____

1. Atmospheric Conditions

   Temperature _____

   Sky Conditions _____

   Wind Speed _____

   Humidity _____

2. Vehicle Fill Nozzle

   Type of Nozzle _____

   Make of car being filled _____

   Explosimeter reading _____

   Operator attempt to make a good fit Yes _____ No _____

3. Vapor Return Line

   Vacuum at Nozzle Yes _____ No _____

   If No, Explain (if reason known)

Kinks or Liquid Blockage in Lines Yes_____ No _____

Does Operator attempt to straighten

lines to minimize liquid blockage Yes _____ No _____

4. Tank Vent

Explosimeter reading _____

5. Tank Drop

Tank Drop made during visit Yes _____ No _____

Volume of Tank Drop (if known) _____

6. Vapor Collection Blower

Explosimeter Reading _____

Condition of drive belts Good _____ Poor _____

7. Surge Tank

Explosimeter Reading _____

Bladder Condition Good _____ Poor _____

8. Compressor

Condition Good _____ Poor _____

Explosimeter Reading

- At Compressor _____
- At Compressor Relief Valves _____

9 Condenser Pressure Relief Valve

Explosimeter Reading _____

10. Refrigeration Unit

Condition Good _____ Poor _____

11. Overall Piping

Explosimeter Reading _____

12. Operational Sequence Check

Vapor collection blower starts with dispensing	Yes _____	No _____
Vapor collection blower stops when dispensing stops	Yes _____	No _____
Compressor starts when level switch in surge tank reaches design level (1/8 capacity)	Yes _____	No _____
Compressor stops when bladder level drops to design shut off level	Yes _____	No _____
Refrigeration unit goes through defrost cycle (30 min.)	Yes _____	No _____

13. Comments

Time In _____ Date _____

Time Out _____ Inspector _____

INSPECTION FORM - [illegible]

Vapor Saver Model No. _____

Station _____

Address _____

1. Atmospheric Conditions

Temperature _____

Sky Conditions _____

Wind Speed _____

Humidity _____

2. Vehicle Fill Nozzle

Type of Nozzle _____

Make of car being filled _____

Explosimeter reading _____

Operator attempt to make a good fit Yes _____ No _____

3. Vapor Return Line

Vacuum at Nozzle Yes _____ No _____

If No, explain (if reason is known)

Kinks or Liquid Blockage in Lines Yes _____ No _____

Does Operator attempt to straighten lines to minimize liquid blockage Yes _____ No _____

4. Tank Vent

Explosimeter reading _____

5. Tank Drop

Tank Drop made during visit Yes _____ No _____

Volume of Tank Drop (if known) _____

6. Inland Blower

Explosimeter reading _____

Condition of drive belt Good _____ Poor _____

7. Vapor Refrigeration Blower

Explosimeter reading _____

Condition of drive belt Good _____ Poor _____

8. Carbon Regeneration Blower

Explosimeter reading _____

Condition of drive belt Good _____ Poor _____

9 Carbon Canister Vent

Explosimeter reading _____

10.

11. Overall Piping

Explosimeter reading _____

12. Operational Sequence Check

Island blower starts with dispensing	Yes _____	No _____
Island blower stops when dispensing stops	Yes _____	No _____
Refrigeration blower starts when tank pressure reaches 1" H_2O	Yes _____	No _____
Refrigeration blower stops after four 15 min. cycles or when tank pressure reaches 1/2" H_2O	Yes _____	No _____
Carbon regeneration blower starts when refrigeration blower stops	Yes _____	No _____

13. Comments

Time in _____ Date _____

Time out _____ Inspector _____

INSPECTION FORM - CLEAN AIR ENGINEERING 5000 & 10000

Model No. _____

Station _____

Address _____

1. Atmospheric Conditions

   Temperature _____

   Sky Conditions _____

   Wind Speed _____

   Humidity _____

2. Vehicle Fill Nozzle

   Type of Nozzle _____

   Make of car being filled _____

   Explosimeter reading _____

   Operator attempt to make a good fit-- Yes_____ No_____

3. Vapor Return Line

   Vacuum at Nozzle Yes _____ No _____

   If No, Explain (If reason is known)

Kinks or Liquid Blockage in Lines Yes _____ No _____

Does Operator Attempt to Straighten Lines to Minimize Liquid Blockage Yes _____ No _____

4. Tank Vent

Explosimeter reading _____

5. Tank Drop

Tank Drop made during visit Yes _____ No _____

Volume of Tank Drop (if known) _____

6. Vapor Collection Blower

Explosimeter reading _____

Condition of Drive Belt Good _____ Poor _____

7. Carbon Canister Vent

Explosimeter reading _____

8. Burner Exhaust

Explosimeter reading _____

9. Overall Piping

Explosimeter reading _____

10. Operational Sequence Check

Vapor Blower starts with dispensing - Yes _____ No _____

Vapor Blower stops when stage two burner stops - Yes _____ No _____

Stage two burner starts when stage one burner stops - Yes _____ No _____

Burner ignition energized when dispensing stops - Yes _____ No _____

11. Comments

Time in _____ Date _____

Time out _____ Inspector _____

INSPECTION FORM - CLEAN AIR ENGINEERING 2500B & 5000B

Model No. _____

Station _____

Address _____

1. Atmospheric Conditions

Temperature _____

Sky Conditions _____

Wind Speed _____

Humidity _____

2. Vehicle Fill Nozzle

Type of Nozzle _____

Make of car being filled _____

Explosimeter reading _____

Operator attempt to make a good fit Yes _____ No _____

3. Vapor Return Line

Vacuum at Nozzle Yes _____ No _____

If No, Explain (if reason is known)

Kinks or liquid blockage in lines Yes _____ No _____

Does Operator attempt to straighten

lines to minimize liquid blockage Yes _____ No _____

4. Tank Vent

Explosimeter reading _____

5. Tank Drop

Tank Drop made during visit Yes _____ No _____

Volume of Tank Drop (if known) _____

6. Vapor Collection Blower

Explosimeter reading _____

Condition of drive belts Good _____ Poor _____

7. Carbon Canister Vent

Explosimeter reading _____

8. Burner Pump

Explosimeter reading _____

Condition of drive belt _____

9. Burner Exhaust

Explosimeter reading _____

10. Overall Piping

Explosimeter reading _____

11. Operational Sequence Check

- Vapor collection blower starts with dispensing - Yes _____ No _____
- Burner pumps start with dispensing Yes _____ No _____
- Burner ignition energized when burner pump starts - Yes _____ No _____
- If neither burner starts, burner pump stops - Yes _____ No _____
- Once burner pump stops, does not start until dispensing starts - Yes _____ No _____
- Second stage burner starts when first stage burner stops - Yes _____ No _____
- Burner pump stops when second stage burner stops - Yes _____ No _____
- Vapor collection blower stops when dispensing stops - Yes _____ No _____

12. Comments

Time In _____ Date _____

Time Out _____ Inspector _____

INSPECTION FORM - ENVIRONICS VAPOX A-3000, A-1500, A-400 & A-400-H

Model No. _____

Station _____

Address _____

1. Atmospheric Conditions

Temperature _____

Sky Conditions _____

Wind Speed _____

Humidity _____

2. Vehicle Fill Nozzle

Type of Nozzle _____

Make of car being filled _____

Explosimeter reading _____

Operator attempt to make a good fit Yes _____ No _____

3. Vapor Return Line

Vacuum at Nozzle Yes _____ No _____

If No, explain (if reason is known)

Kinks or Liquid Blockage in lines Yes _____ No _____

Does Operator attempt to straighten lines to minimize liquid blockage Yes _____ No _____

4. Tank Vent

Explosimeter reading _____

5. Vapor Collection Blower

Explosimeter reading _____

Condition of drive belt Good _____ Poor _____

6. Carbon Canister Vent

Explosimeter reading _____

7. Reactor Vent

Explosimeter reading _____

Reactor down due to 1300°F override during visit Yes _____ No _____

8. Carbon Regeneration Blower

Explosimeter reading _____

Condition of drive belt Good _____ Poor _____

9. Overall Piping

Explosimeter reading _____

10. Operational Sequence Check

Vapor A-3000

Vapor Collection Pump starts with dispensing	Yes _____	No _____
Pressure switch opens at 3.5" H_2O	Yes _____	No _____
Vapor collection pump stops when dispensing stops-	Yes _____	No _____
Carbon regeneration pump stops when reactor temperature is below 900°F or above 1300°F.	Yes _____	No _____

Vapor A-1500, A-400 & A-400-M

Vapor collection blower starts with dispensing	Yes _____	No _____
Pressure switch opens at 3.5" H_2O	Yes _____	NO _____
Vapor collection blower stops when dispensing is over-	Yes _____	No _____
Carbon regeneration blower starts when dispensing is over-	Yes _____	No _____
Carbon regeneration blower stops when dispensing starts-	Yes _____	No _____
Carbon regeneration stops when reactor temperature is below 900°F or above 1300°F	Yes _____	No _____

11. Tank Drop

Tank Drop made during visit Yes _____ No _____

Volume of Tank Drop (if known) _____ ± _____

12. Comments

Time In _____ Date _____

Time Out _____ Inspector _____

INSPECTION FORM - HIRT/HAZELETT

Station _____

Address _____

I. Atmospheric Conditions

Temperature _____

Sky Conditions _____

Wind Speed _____

Humidity _____

II. Vehicle Fill Nozzle

Type of Nozzle _____

Make of car being filled _____

Explosimeter reading _____

Operator attempt to make a good fit Yes _____ No _____

III. Vapor Return Line

Vacuum at Nozzle Yes _____ No _____

If No, Explain (if reason is known)

Kinks or Liquid Blockage in Lines Yes _____ No _____

Does Operator attempt to straighten lines to minimize liquid blockage Yes _____ No _____

4. Tank Vent

Explosimeter reading _____

5. Tank Drop

Tank Drop made during visit Yes _____ No _____

Volume of Tank Drop (if known) _____

6. Burner Exhaust

Explosimeter reading _____

Pilot operating during visit Yes _____ No _____

7. Propane Gas Supply

Satisfactory _____ Unsatisfactory _____

8. Compressed Air Supply

Satisfactory _____ Unsatisfactory _____

9. Overall Piping

Explosimeter reading _____

10. Operational Sequence Check

Compressed Air starts when tank pressure reaches -0.15" H_2O Yes _____ No _____

Small burner comes on when tank pressure reaches -0.15" H_2O Yes _____ No _____

Large burner comes on when tank pressure reaches +0.1" H_2O Yes _____ No _____

Compressed air stops when tank pressure reaches -0.23" H_2O (for small burner) Yes _____ No _____

Compressed air stops when tank pressure reaches -05"H_2O (for large burner) Yes _____ No _____

11. Comments

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	–	[illegible]	1	–	[illegible] – [illegible]	–
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	–	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]
[illegible]	–	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible] [illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	–
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	–
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible] [illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	–	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	–	1	–	[illegible]	[illegible]
[illegible]	[illegible]	–	1	–	[illegible] – [illegible]	[illegible]
[illegible]	–	[illegible]	1	–	[illegible] – [illegible]	[illegible]
[illegible]	–	[illegible]	1	–	[illegible] – [illegible]	–
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	–	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible] – [illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	–	2	–	[illegible] – [illegible]	[illegible] [illegible]
[illegible]	–	[illegible]	2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	–	[illegible] – [illegible]	[illegible] [illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
–	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Ford	Falcon	1962	4	Left Rear Panel	0	–
Chevy	Yoga Wagon	1972	4	Right Rear Panel	0	–
Ford	Mustang	1969	4	Rear Panel	0	–
Ford	Pickup	1961	4	Left Rear Panel	0	–
Vw	Bus	1971	4	Right Rear Panel	1.0 – 10L	Rear Fix
Opel	Coupe	1970	4	Right Rear Panel	0	–
Volvo	Sta.Wag.	1967	4	Right Rear Panel	0	–
Toyota	Pickup	1973	4	Right Mid Panel	0	–
Chevy	Yoga	1971	4	Under License Plate	1.0 – 10L	Needs Body Repairs
Datsun	240B	1972	4	Right Rear Panel	0	–
Mercury	Capri	1972	4	Right Front Panel	1.0 – 10L	–
Vw	Rabbit	1975	4	–	0	Dent Fix
Vw	Bug	1969	4	–	0	–
Pontiac	Sta.Wag.	1974	4	–	0	–
Vw	Bug	1974	4	–	0	–
Datsun	210	–	4	Right Rear Panel	1000 Mile	–
Chevy	Chevelle	1970	4	–	1.0 – 10L	Rear Fix
Ford	Pinto Wagon	1973	5	Left Rear Panel	0	–
Chevy	GMC	1972	5	Left Rear Panel	0	–
Volvo	Sta.Wag.	1974	5	Left Rear Panel	0	–
Buick	Le Sabre	1971	5	Under License Plate	0	–
Chevrolet	MC 10	1972	5	Under License Plate	0	–
Vw	Sta.Wag.	1971	5	Right Front Panel	0	–
Chevy	EC Cadillac	1968	5	Left Rear Panel	0	–
Ford	LeCoCoss	1967	5	Left Rear Panel	0	–
Buick	Regal	1972	5	–	0	–
Plymouth	–	1969	5	–	0	–
Ford	Pinto Wagon	1974	5	–	0	–
Datsun-nissan	–	1972	5	–	0	–
Lincoln	Continental	1974	5	Left Rear Panel	1.0 – 10L	–
Toyota	–	1971	5	Under License Plate	0	–
Dodge	Van	1963	5	Left Rear Panel	0	–
Chevy	Van	1974	5	Left Rear Panel	0	–
Plymouth	Fury	1969	5	Under License Plate	0	–
Vw	Bug	1967	5	Right Front Panel	0	–

[illegible] TESTED (cont.)

Make	Model	Year	Station Number Where Tested	Full Size Location	DC Deflection	Comments
[illegible]	[illegible]	[illegible]	7	[illegible] License Plate	0	--
[illegible]	[illegible]	[illegible]	7	Left Side Panel	0	--
[illegible]	[illegible]	[illegible]	[illegible]	--	[illegible]	[illegible]
[illegible]	--	[illegible]	7	[illegible] License Plate	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7	Left Rear Panel	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7	--	0	--
[illegible]	--	[illegible]	7	Behind Right Door	0	--
[illegible]	[illegible]	[illegible]	7	Inside Trunk	[illegible]	--
[illegible]	[illegible]	[illegible]	7	Rear Panel	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7	Rear Panel	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	Left Rear Panel	0	--
[illegible]	[illegible]	[illegible]	7	Left Rear Panel	0	--
[illegible]	[illegible]	[illegible]	7	Left Front Panel	0	--
[illegible]	[illegible]	[illegible]	7	Left Rear Panel	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	7	Left Rear Panel	--	--
[illegible]	[illegible]	[illegible]	7	Left Rear Panel	[illegible]	--
[illegible]	[illegible]	[illegible]	7	Rear Panel	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6	--	[illegible]	[illegible]
[illegible]	--	[illegible]	6	--	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6	Rear Panel	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6	[illegible] License Plate	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6	Left Rear Panel	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6	Rear Panel	0	--
[illegible]	[illegible]	[illegible]	6	Right Rear Panel	0	--
[illegible]	--	[illegible]	6	[illegible] License Plate	0	--
[illegible]	[illegible]	[illegible]	6	[illegible] License Plate	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6	[illegible] License Plate	0	[illegible]
[illegible]	[illegible]	[illegible]	6	Behind Left Door	0	--
[illegible]	[illegible]	[illegible]	6	Left Rear Panel	0	--
[illegible]	[illegible]	[illegible]	6	Right Rear Panel	[illegible]	[illegible]
[illegible]	--	[illegible]	6	[illegible] License Plate	0	--
[illegible]	--	[illegible]	6	[illegible] License Plate	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	6	[illegible] License Plate	[illegible]	[illegible]

VEHICLES TESTED (cont)

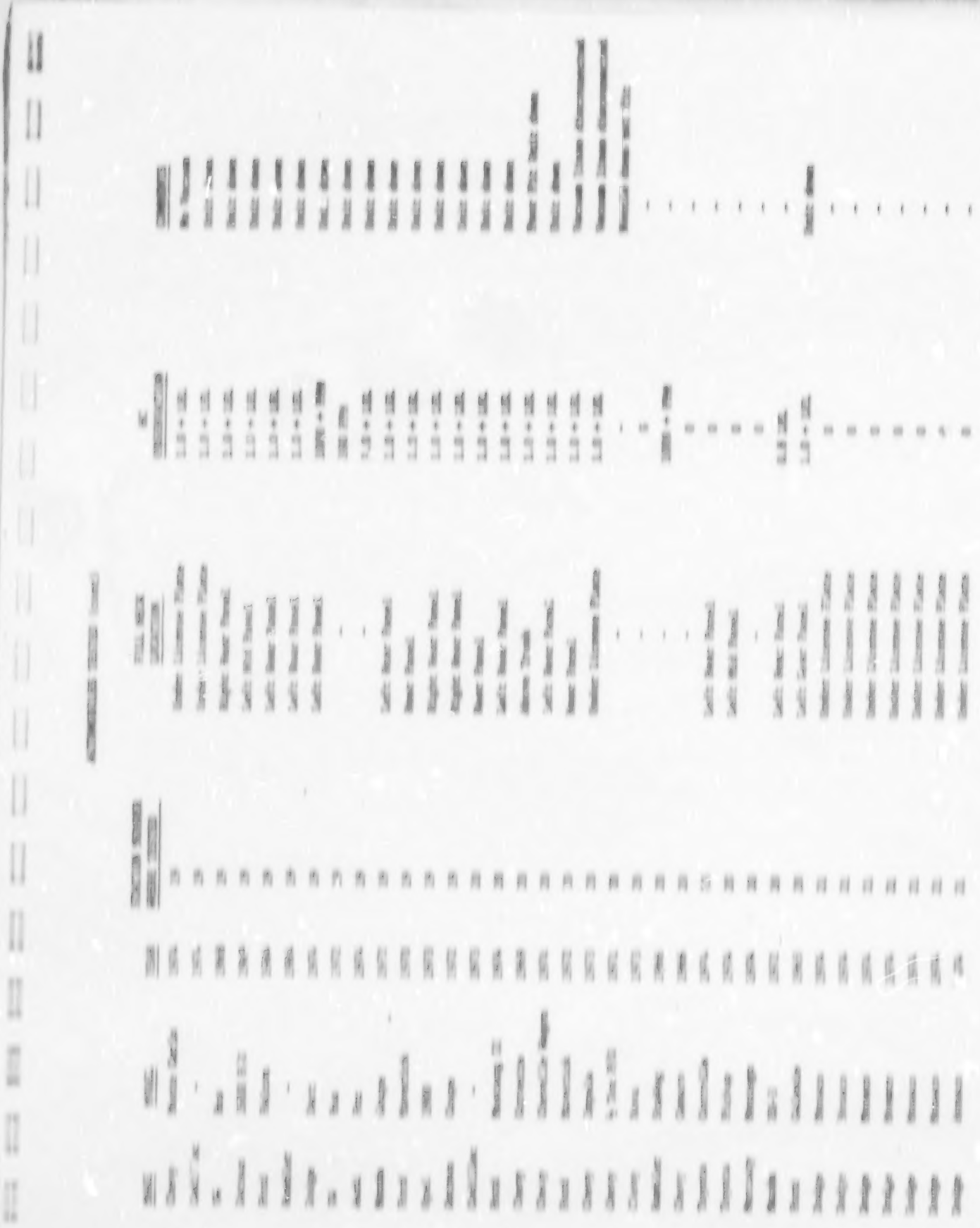
MAKE	MODEL	YEAR	ENGINE NUMBER AUDIO TESTED	FULL AREA LOCATION	HC CONTAMINATION	COMMENTS
Ford	Galaxie	1967	11	Left Rear Panel	0	Ex22-Ganna
Mercury	Comet	1964	11	-	2	Ex22-Ganna
Ford	3/4 Ton P/U	1966	11	-	1000+PPM	Ex22-Ganna
Ford	Ranchero	1977	11	-	0	Ex22-Ganna
Ford	Galaxie	1966	11	-	0	Ex22-Ganna
Datsun- MICRONA	Truck(A12)	1969	11	-	0	Ex22-Ganna
Jeep	-	1972	11	-	0	Ex22-Ganna
Pontiac	GTO	1967	11	-	0	Ex22-Ganna
Buick	Riviera	1966	11	Under License Plate	0	Ex22-Ganna
Mercury	Cougar	1970	11	Under License Plate	0	Ex22-Ganna
Chevy	Vega	1971	11	-	0	Ex22-Ganna
Dodge	Polara	1972	11	-	0	Ex22-Ganna
Buick	Le Sabre	1970	11	-	0	Ex22-Ganna
VW	Bus	1971	11	Right Rear Panel	0	Ex22-Ganna
Ford	3/4 Ton P/U	1970	11	-	0	Ex22-Ganna
Chevy	Sta.Wag.	1972	11	-	0	Ex22-Ganna
Oldsmobile	98	1971	11	-	2	-
Chevy	Nova	1970	11	Under License Plate	0	-
Ford	Falcon	-	11	-	0	-
Chevy	Van	1970	11	-	0	-
Ford	-	1972	11	Left Rear Panel	0	Ex22-Ganna
Chev	Camaro	1973	11	Under License Plate	0	Ex22-Ganna
Chevy	Pickup	1974	11	Behind Door	0	-
Toyota	Pickup	1969	11	Left "Cab" Panel	0	-
Chevy	Nova Wagon	1969	11	Left Rear Panel	0	Rear Air
Mercury	Cougar	1970	11	Under License Plate	0	-
Ford	Maverick	1972	11	Rear Panel	0	-
VW	Sqg	1970	11	Right Front Panel	0	-
Pontiac	Ventura	1972	11	Under License Plate	0	Ex22-Ganna
AMC	Javelin	1968	11	Under License Plate	0	Ex22-Ganna
Jeep	Pickup	1974	11	Pickup Left Door	0	Ex22-Ganna
Chev	Van	1972	11	Under License Plate	0	Ex22-Ganna
Datsun	-	1968	11	Right Rear Panel	0	Ex22-Ganna
Buick	Skylark	1972	11	Under License Plate	0	Ex22-Ganna
VW	Bus	1969	11	Right Rear Panel	0	Ex22-Ganna
Chevy	Impala	1964	11	Left Rear Panel	0	Ex22-Ganna

AUTOMOBILES TESTED (cont)

MAKE	MODEL	YEAR	FUNCTION NUMBER WHERE TESTED	FUEL TANK LOCATION	SC DEFLECTION	COMMENTS
Chrysler	Imperial	1970	13	Outer License Plate	1.0 + 10%	3x10-Series
Mercury	Cougar	1972	13	Right Front Panel	1.0 + 10%	3x10-Series
Dodge	Dart	1964	13	Left Rear Panel	1.0 + 10%	3x10-Series
Pontiac	Le Mans	1974	13	Outer License Plate	1.0 + 10%	-
Dodge	Dart	1974	13	Left Rear Panel	0-100 mm	-
Ford	LTD	1972	13	Left Rear Panel	1.0 + 10%	3x10-Series Rear Fit
Chevy	Sta.Wag.	1970	13	Left Rear Panel	1.0 + 10% 0 mm	3x10-Series Windshield Tears
Ford	Fiesta	1974	13	Left Rear Panel	0-100 mm	3x10-Series
Ford	Mustang	1969	13	Rear Panel	0	ea10-Series
Ford	Pinto	1972	13	-	0	-
Chevy	C10 Truck	1971	13	-	1.0 + 10%	-
Datsun	1200 F/C	1961	13	-	0-1000 mm	-
Chevy	El Camino	1963	13	-	1000 + mm	-
Chevy	Camaro	1967	13	-	0	Crash Occ
Ford	Pinto	1971	13	Left Rear Panel	0	Crash Occ
Pontiac	Catalina	1969	13	Outer License Plate	1000 mm	Rear Occ
Ford	Pinto	1974	14	Left Rear Panel	-	Rear Occ down to hood hold
Chrysler	Le Baron	1968	14	-	5.2 LE	Crash Occ.
VW	"Thing"	1973	14	-	0	Hood hold
Ford	Thunderbird	1969	14	-	1.0 + 10%	-
Chevy	Van	1971	14	-	1000 + mm	-
AMC/Jeep	-	1972	14	-	1000 + mm	-
VW	Beetle	1974	14	-	1000 + mm	-
Ford	Pinto	1972	14	Left Rear Panel	1.0 + 10%	3x10-Series wrestle hit, mat of rear door sec door
Dodge	Sta.Wag.	1971	14	Left Rear Panel	1.0 + 10%	Rear Occ
Ford	Custom 500	1974	14	Right Rear Panel	1.0 + 10%	3x10-Series
VW	-	1968	14	Right Rear Panel	1.0 + 10%	3x10-Series
Datsun	Pickup	1971	14	Left Rear Panel	1.0 + 10%	3x10-Series
Ford	Mustang	1969	14	Rear Panel	1.0 + 10%	3x10-Series
Plymouth	-	1969	14	Left Rear Panel	0	-
Plymouth	Sta.Wag.	197	14	Left Rear Panel	1.0 + 10%	3x10-Series
Mercedes	-	1971	14	Outer License Plate	1.0 + 10%	Rear Fit
Chevy	Sta.Wag.	1970	14	Left Rear Panel	0	3x10-Series
VW	Bus	1969	14	Right Rear Panel	1.0 + 10%	3x10-Series

[illegible] TESTS (cont)

| [illegible] | MAKE | MODEL | YEAR | [illegible] | [illegible] | [illegible]



Year	Model	Time	Station Wagon Model Theft	Theft Location	AC Interaction	Comments
Dodge	Monaco	1974	21	Under Left Rear Fender	0	–
Dodge	Monaco	1974	21	Under Licensee Plate	100 PPM	–
Dodge	Polara	1974	21	Under Licensee Plate	0	–
Dodge	Monaco	1974	21	Under Licensee Plate	0	–
Dodge	Dart	1973	21	–	0	–
Dodge	Polara	1973	21	–	0	–
Dodge	Monaco	1974	21	Rear Panel	0	–
Dodge	Monaco	1974	21	Rear Panel	0	–
Dodge	Monaco	1974	21	Rear Panel	0	–
Dodge	Monaco	1974	21	Rear Panel	0	1.0 + 125, at end of [illegible]
Dodge	Monaco	1974	21	Rear Panel	0	–
Dodge	Monaco	1974	21	Rear Panel	0	–
Plymouth	Le Baron	1965	21	Under License	1000 + PPM	Two Winds around post fire
Dodge	Coronet	1968	21	Under Licensee Plate	0	
Dart	Swinger	1973	21	–	1000 + PPM	Rear Fir.
Plymouth	Belvedere	1964	21	–	100 PPM	–
Dodge	Coronet Wagon	1965	21	–	0	–
Dart	Swinger Special	1970	21	Under Licensee Plate	0	–
Jeepster	–	1970	21	Right Rear Panel	0	–
Dodge	Coronet	1968	21	Under Licensee Plate	0	–
Dodge	Coronet Wagon	1972	21	Left Rear Panel	0	–
Dart	Sega	1972	21	Under Licensee Plate	0	–
Ford	Econoline	197–	21	Left Rear Panel	0	–
Ford	Maverick	1972	21	Rear Panel	0	–
Dodge	Coronet Wagon	1972	21	Left Rear Panel	0-450 PPM	Rear Fir.
Ford	Econoline	1972	21	–	0	Dead Fir.
Buick	Electra	1967	21	Under Licensee Plate	1.0 + 125,	Rear Vacuum
Ford	Mustang	1968	21	Rear Panel	1.0 + 125,	Rear Vacuum
Ford	Fairlane	1964	21	Rear Panel	1.0 + 125,	Rear Vacuum
Ford	Torino	1968	21	Rear Panel	1.0 + 125,	Rear Fir. Rear Vacuum
Dodge	–	1972	21	Under Licensee Plate	1.0 + 125,	Rear Vacuum
Plymouth	–	1968	21	Left Rear Panel	0	Split back at end of [illegible]
Ford	Maverick	1974	21	Left Rear Panel	0	Split back at end of [illegible]
Ford	Torino	1972	21	Under Licensee Plate	0	–

APPENDIX C
Measured Operational Parameters

I. INTERMARK SYSTEMS

Date of Visit	Station Location	Comments
7/1/75	Deere	Bladder level indicator read 1/5 capacity, pressure = 0.65" H_2O.
7/9/75	Deere	Bladder down, pressure = 0.45" H_2O, compressor came on when level indicator read 1/8 capacity, pressure = 2" H_2O.
7/2/75	Gemco	Pressure = 1.5" H_2O when bladder level indicator read 1/8-1/8 capacity, pressure = 0.35" H_2O when level indicator read 1/16 - 1/8 capacity and compressor turned off, pressure = 1.0" H_2O when level indicator read just under 1/8 capacity and compressor started.
7/9/75	Gemco	Bladder in down position, pressure = 0.45" H_2O, pressure = 1.4" H_2O when level indicator read 1/8 capacity.
7/30/75	Gemco	Bladder in full up position, pressure = 7.5" H_2O.
7/1/75	Encinitas	Pressure = 2.6" H_2O, corresponding bladder level not known because level indicator does not work.
7/10/75	Encinitas	Pressure = 0" H_2O, processing unit down.
7/10/75	Carmel Valley	Pressure = 0" H_2O, processing unit down.

II. PROCESS PRODUCTS SYSTEMS & TEMPERATURE DATA

6/18/75	Waring Road	Refrigeration unit starts at 5" H_2O stops at 0.5" H_2O.
6/30/75	Waring Road	Refrigeration unit starts at 3.5 - 3.8" H_2O, stops at 0.5" H_2O
7/8/75	Waring Road	Refrigeration unit starts at 4.5" H_2O, stops at 0.5" H_2O

II. PROCESS PRODUCTS SYSTEMS & TEMPERATURE DATA (cont)

Date of Visit	Station Location	Comments
7/16/75	Waring Road	Refrigeration unit starts at 4.5" H_2O, stops at 0.5" H_2O
7/23/75	Waring Road	Refrigeration starts at 4.5" H_2O, stops at 0.5" H_2O
7/29/75	Waring Road	Refrigeration starts at 4.5" H_2O, stops at 1" H_2O.
6/19/75	Peters & Frasse	Condensate return = 12F, no pressure data
6/23/75	Peters & Frasse	Refrigeration starts at 1.1" H_2O, stops at 0.5" H_2O
6/26/75	Peters & Frasse	Condensate return = 22F, no pressure data
7/3/75	Peters & Frasse	Refrigeration starts at 1" H_2O, stops at 0.5" H_2O.
7/9/75	Peters & Frasse	Condensate return = 30F, refrigeration starts at 1.1" H_2O, stops at 0.3" H_2O
7/17/75	Peters & Frasse	Refrigeration starts at 1" H_2O, stops at 0.5" H_2O
7/23/75	Peters & Frasse	Condensate return = 30F, refrigeration starts at 1.1" H_2O, stops at 0.5" H_2O.
7/30/75	Peters & Frasse	Condensate return = 40F, refrigeration starts at 1" H_2O, stops at 0.5" H_2O
7/15/75	Clairmont & Clairmont Mesa	Tank pressure at 0.6" H_2O, processing unit down
7/22/75	Clairmont & Clairmont Mesa	Tank pressure 0" H_2O, unit down.
7/9/75	Bubble Machine	Tank pressure = 3.5" H_2O, unit down.

III. CLEAN AIR ENGINEERING SYSTEMS

6/25/75	Tierrasanta	Manifold pressure = 3" H_2O.
6/30/75	Tierrasanta	Manifold pressure = 3.5" H_2O.
7/8/75	Tierrasanta	Manifold pressure = 3.5" H_2O (low pressure adjusted to reduce snoring, according to Clean Air).
7/22/75	Tierrasanta	Manifold pressure = 3.2" H_2O while burning.
7/29/75	Tierrasanta	Manifold pressure = 3.3" H_2O

III. CLEAN AIR ENGINEERING SYSTEMS (cont)

Date of Visit	Station Location	Comments
6/26/75	Highway Patrol, S.D.	Manifold pressure = 5.5" H_2O
7/2/75	Highway Patrol, S.D.	15" H_2O when just vapor recovery blower on, 5.5" H_2O when burner pump starts, when burner pump stopped pressure went to -3" H_2O but leveled to zero after 5 min.
7/10/75	Highway Patrol, S.D.	Manifold pressure = 5" H_2O.
7/15/75	Highway Patrol, S.D.	Manifold pressure = 5.5" H_2O while burning.
7/28/75	Highway Patrol, S.D.	Manifold pressure = 5.3" H_2O
6/30/75	Rocky Home Dairy	14.5" H_2O when vapor collection blower on, pressure went to 6.8" H_2O when burner on.
7/9/75	Rocky Home Dairy	Pressure goes to 15" H_2O when vapor collection blower starts, as burner starts pressure decreases to 6.5" H_2O.
7/16/75	Rocky Home Dairy	Manifold Pressure = 6.8" H_2O while burning
7/22/75	Rocky Home Dairy	Manifold Pressure = 6.3" H_2O.
7/28/75	Rocky Home Dairy	Manifold Pressure = 6.2" H_2O.
7/3/75	Highway Patrol, Meade	5.5" H_2O while burner pump on, 15" H_2O before burner activated.
7/10/75	Highway Patrol, Meade	15" H_2O before burner pump on, 5-3/4" H_2O after burner pump started.
7/18/75	Highway Patrol, Meade	Manifold pressure = 5.3" H_2O
7/31/75	Highway Patrol, Meade	Manifold pressure = 5.0" H_2O

IV. BIBT SYSTEM DATA

7/10/75	Oceanside	Compressed air starts when tank pressure = -0.18" H_2O, small burner starts when tank pressure = -0.18" H_2O.

IV. HIRT SYSTEM DATA (cont)

Date of Visit	Station Location	Comments
		compressed air and burners stop when tank pressure = -0.65" H_2O (large burner starts when tank pressure = -0.1" H_2O, this was not observed but information was supplied by Hirt)
7/15/75	Oceanside	Compressed air starts when tank pressure = -0.61" H_2O, small burner starts when pressure = -0.61" H_2O.
7/31/75	Oceanside	Compressed air and small burner start when tank pressure = -0.38" H_2O, both stop when tank pressure = -0.61" H_2O.

V. ENVIRONICS SYSTEMS

7/1/75	Parkway Texaco	Reactor Temp. = 73F (?), unit down.
7/9/75	Parkway Texaco	Reactor Temp. = 1065F.
7/16/75	Parkway Texaco	Reactor starts at 1290F, carbon regeneration pump deactivates when temp. reaches 740F.
7/29/75	Parkway Texaco	Pressure switch at 1.6" H_2O, 2.6" H_2O when vapor collection blower starts then back to 1.6" H_2O.
7/2/75	Post Office	Reactor Temp. at 848F when burner pump came on, then went down to 760F.
7/10/75	Post Office	Reactor temp at 872F before any gas fillups.
7/17/75	Post Office	Processing unit down, reactor temp = 835F.
7/31/75	6th & Robinson	Pressure switch opened at 1.5" H_2O.

AUTOMOBILES WITH FILLNECKS POORLY FIT BY NOZZLES

Maker	Model	Year	Location of Fillneck
BMW	-	1969	Right Rear Side
Buick	Riviera	1966	Under License Plate
Buick	Sta. Wag.	1967	
Chevy	Malibu	1973	
Chevy	Corvette	1966	On Top Of Trunk
Chevy	El Camino	-	Left Rear Side
Chevy	Nova Wagon	1968	Left Rear Side
Chevy	Corvette	1969	On Top Of Trunk
Chevy	1/2 Ton Pickup	1971	(Nozzle Did Not Fit)
Chevy	Van	1975	
Chevy	Chevelle	1973	
Chevy	350 Truck	1973	Below Cab On Right Side
Chevy	L/50 Truck	1968	Behind Left Cab Door
Chevy	Corvette	1969	On Top Of Truck
Datsun	Sta. Wag.	1971	Right Rear Side
Datsun	1600	1973	Right Rear Side
Datsun	240z	1973	Right Rear Side
Datsun	240z	1969	Right Rear Side
Datsun	Sta. Wag.	1967	Under License Plate
Datsun	Pickup	1975	Left Rear Side
Dodge	Coronet Wagon	1973	On Left Rear Side
Dodge	Satellite	1974	Under License Plate
Dodge	Sta. Wag.	1973	Left Rear Side

AUTOMOBILES WITH FILLNECKS POORLY FIT BY NOZZLES (Continued)

Maker	Model	Year	Location of Fillneck
Dodge	Polara	1967	Under License Plate
Fiat	128	1973	
Ford	LTD	1972	Left Rear Side
Ford	Falcon	1964	Left Rear Side
Ford	Pickup	-	
Ford	Maverick	1970	At Rear
Ford	Torino	1973	Under License Plate
Ford	5 Ton Truck	1976	
Ford	Falcon	1968	At Rear
Mercedes	-	1971	Under License Plate
Oldsmobile	98	1968	Under License Plate
Pontiac	Le Mans	1965	Under License Plate. Tow Hitch Hindered Fit.
Pontiac	Catalina	1966	Under License Plate
Pontiac	-	1968	
VW	Bus	1971	Right Rear Side
VW	Bug	1966	Inside Trunk
VW	-	1972	Right Front Side

Poor fits can be due to obstructions such as towing hitches, pop-up gas caps, anti-syphon devices, door hatches over fill necks, etc.

OBSERVATIONS WITH EPA HYDROCARBON DETECTORS

1. Clean Air Engineering Systems

Date of Visit	Station Location	HC Detector Reading	Comments
6/10/75	Rocky Home Dairy	10.6 Hr	Start time on detector was 10.6 Hr, detector installed was #245-3 504-3 Probe #5 (Latching Type)
6/18/75	Rocky Home Dairy	10.6 Hr	
6/19/75	Rocky Home Dairy	No Reading	
6/24/75	Rocky Home Dairy	10.6 Hr	
6/30/75	Rocky Home Dairy	10.6 Hr	
7/8/75	Rocky Home Dairy	10.6 Hr	
7/16/75	Rocky Home Dairy	10.6 Hr	Recorded as 0.6 Hr on data sheet, but detector will not run in reverse and not enough hours had passed to complete a total revolution of the timer, so reading was assumed to be 10.6 Hr
7/22/75	Rocky Home Dairy	No Reading	
7/28/75	Rocky Home Dairy	10.6 Hr	Recorded as 0.6 Hr
6/17/75	Highway Patrol, S.D.	0.5 Hr	Start time on detector was 0.5 Hr, detector installed was #245-2, 504-1, Probe #2 (Non-latching Type)
6/26/75	Highway Patrol, S.D.	No Reading	
7/2/75	Highway Patrol, S.D.	0.5 Hr	
7/10/75	Highway Patrol, S.D.	0.5 Hr	
7/15/75	Highway Patrol, S.D.	0.5 Hr	
7/28/75	Highway Patrol, S.D.	0.5 Hr	

OBSERVATIONS WITH EPA HYDROCARBON DETECTORS (Continued)

II. Environics Systems

Date of Visit	Station Location	HC Detector Reading	Comments
6/11/75	Midway Post Office	0.2 Hr	Start time on detector was 0.2 Hr, detector installed was #245-3 504-1, Probe #6 (Latching Type)
6/24/75	Midway Post Office	306.5 Hr	Read at 0830 and reset with start at 306.6 hr
6/27/75	Midway Post Office	306.6 Hr	Upon visit found main power to processing unit off. Reason unknown.
7/3/75	Midway Post Office	306.6 Hr	Blower failure observed during visit.
7/10/75	Midway Post Office	306.6 Hr	Blower still not repaired
7/17/75	Midway Post Office	306.6 Hr	Blower still not repaired
7/31/75	Midway Post Office	306.6 Hr	Blower repaired
6/10/75	Parkway Texaco	0.35 Hr	Start time on detector was 0.35 Hr, detector installed was #245-2, 504-1, Probe #3 (Non-Latching Type)
6/17/75	Parkway Texaco	No Reading	
6/18/75	Parkway Texaco	0.40 Hr	
6/26/75	Parkway Texaco	0.45 Hr	
7/1/75	Parkway Texaco	0.80 Hr	
7/9/75	Parkway Texaco	1.6 Hr	
7/16/75	Parkway Texaco	2.4 Hr	
7/29/75	Parkway Texaco	2.6 Hr	

OBSERVATIONS WITH EPA HYDROCARBON DETECTORS (Continued)

III. PROCESS PRODUCTS SYSTEMS

Date of Visit	Station Location	HC Detector Reading	Comments
6/19/75	Friars & Frazee	0.3 Hr	Start time on detector was 0.3 Hr, detector installed was #245-2, 504-2, Probe #1 (Latching Type)
6/23/75	Friars & Frazee	0.3 Hr	
6/26/75	Friars & Frazee	0.3 Hr	
7/3/75	Friars & Frazee	0.3 Hr	
7/9/75	Friars & Frazee	0.3 Hr	
7/17/75	Friars & Frazee	No Reading	HC Detector disconnected by ARB so they could do their own testing
7/23/75	Friars & Frazee	No Reading	
7/30/75	Friars & Frazee	0.3 Hr	
6/17/75	College Car Wash	No Reading	Processing unit down Detector installed was #245-3, 504-2, Probe #4 (Non-latching Type)
6/18/75	College Car Wash	No Reading	Processing unit down
7/2/75	College Car Wash	No Reading	Processing unit down
7/11/75	College Car Wash	0.2 Hr	Processing unit down Found blown fuse in detector
7/17/75	College Car Wash	No Reading	Processing unit down
7/23/75	College Car Wash	No Reading	Processing unit down
7/30/75	College Car Wash	No Reading	Processing unit down